JANUARY 1959

Power Engineering

ATOMICS ..... Special Bi-Monthly News Report From the Field 33

WHAT'S AHEAD in POWER ENGINEERING — Leading Power Engineers Tell What's Ahead In: Design Trends; Turbine Generators; Tomorrow's Boilers; Hydro Power; Generation and Transmission; Instrumentation; Heat Pumps; Water and Waste Control; Gas Turbines; Power Plant Management; Nuclear Power; Diesel Engines; Power Piping S-1 To S-10

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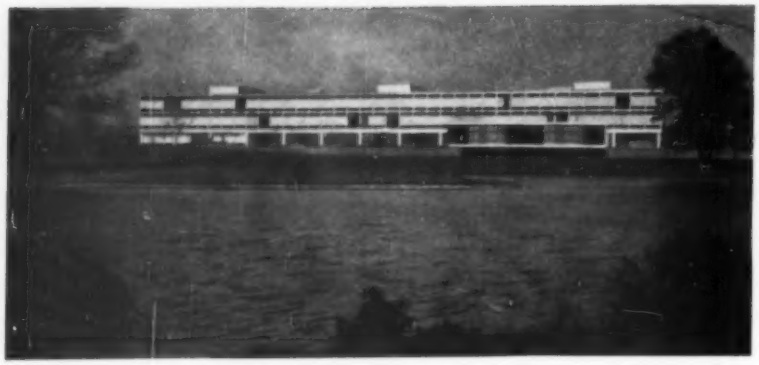
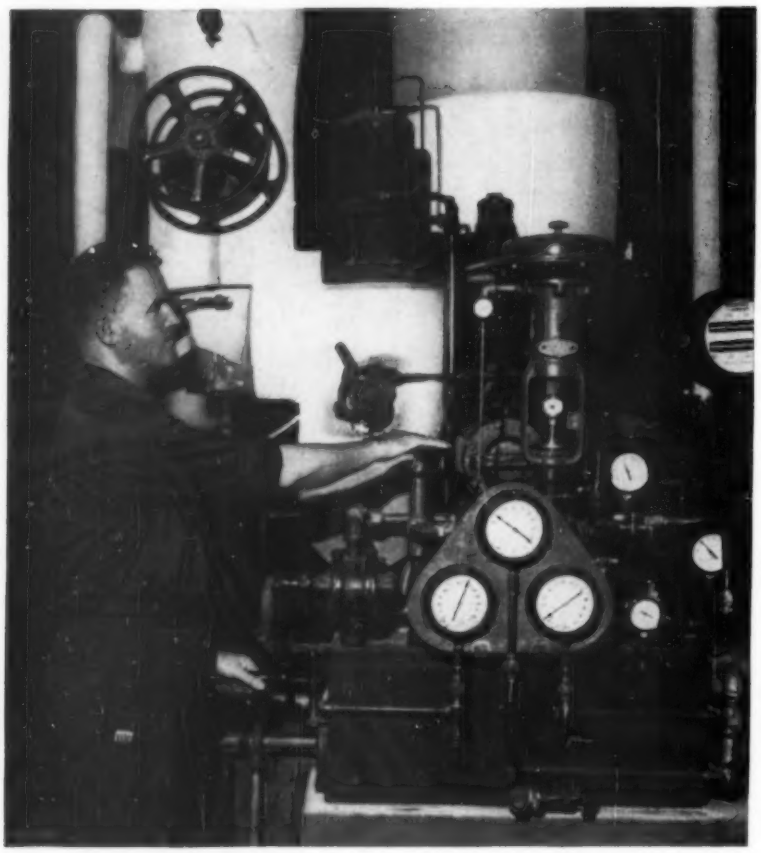


New home office for Connecticut General Life is a modern structure five miles out in the country.

Terry turbines power air-conditioning system at new Connecticut General Life building



One of two 870-hp, 3970-rpm Terry turbines built to drive the refrigeration compressors.

The new home office of the Connecticut General Life Insurance Co., in suburban Hartford, represents the best in contemporary architecture as well as construction techniques and materials.

In keeping with the careful planning evident throughout the project, two Terry turbines were selected to drive the York centrifugal refrigeration compressors. Terry turbines such as these have a record of low maintenance and consistent reliability under varied conditions. The steam generators, which are used for general heating during the winter months, furnish the power to operate the turbines. This provides an economical and dependable air-conditioning setup.

The steel and glass building accommodating 2500 employees overlooks New England farmland. It is furnished with modern equipment, to step up the efficiency of clerical work. Other amenities: lounges, game rooms, cafeteria, bowling alleys, barber and beauty shops, variety store, medical department.

If you are planning an air-conditioning system, perhaps you, too, should consider steam-turbine drive. Write for detailed information about the advantages of turbines for your specific requirements.

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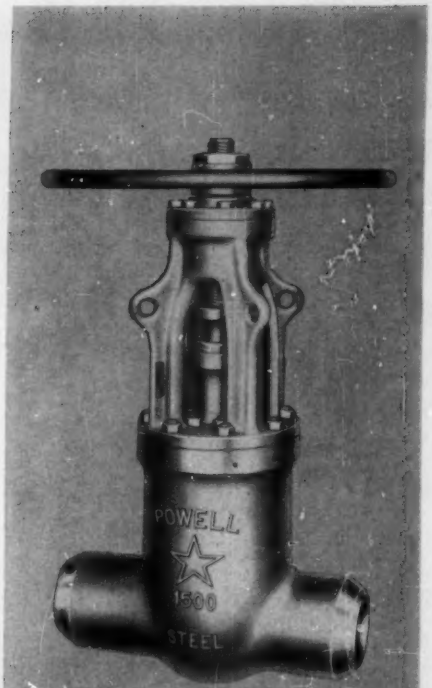

Fig. 11303 W. E.: Steel O. S. & Y. pressure seal gate valve for 1500 pounds W. P. at high temperatures. Powell pressure seal valves are available for working pressures from 600 through 2500 pounds.

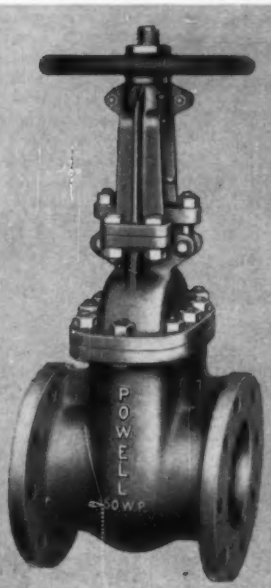

Fig. 86190: Steel union bonnet globe valve for 400 W.O.G. Designed for liquified petroleum gas service.

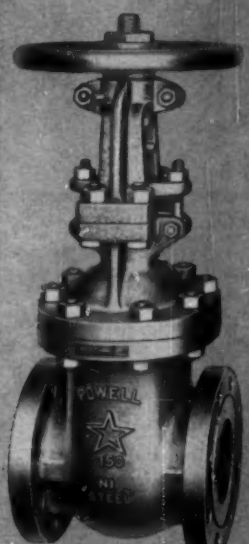

Fig. 2453G: Large 150 pound stainless steel O. S. & Y. gate valve for low temperature service. Can be furnished with interchangeable solid or double wedge disc.

Fig. 1503 Mod.: 3½% Nickel-steel O. S. & Y. gate valve for low temperature service.

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CITY OF MANITOWOC INSTALLS SIXTH WICKES BOILER

R. E. Cannard—Chief Engineer and General Manager

Manitowoc Public Utilities Commission has just installed the sixth Wickes Steam Generator to help provide power for the City of Manitowoc, Wisconsin, and its surrounding area. The continued selection of Wickes equipment by this progressive municipality is a tribute to the dependability and quality of Wickes Steam Generators.

Wickes Boiler Co. builds steam generators for all branches of industry . . . for municipalities and for private and public buildings. Wickes units are available in sizes up to 500,000 lbs. of steam per hour and are designed for high or low steam pressures and temperatures, and for all types of fuels and firing methods. There is a Wickes design available for your needs.

Write for bulletin 55-1, showing the wide variety of designs and sizes available in both field-erected and shop-assembled* steam generators, or ask the nearest Wickes representative to call on you for full information.

*For the latest developments in shop-assembled boilers, investigate Wickes natural circulation A-type water tube units now built for capacities up to 75,000 lbs. per hour for oil and gas fuels. Request bulletins 56-1 and 57-1 for full information.

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NBP BPA

PUBLISHED SINCE 1896 FOR POWER ENGINEERS IN PRIVATE AND PUBLIC UTILITIES AND INDUSTRIAL PLANTS

ENGINEERS' PREVIEW

IN THE NEWS as the year opens: Public Service Electric and Gas Company has programmed the first all-aluminum transmission towers in the United States, in coöperation with Aluminum Company of America. The New Jersey utility plans to use over 60 such towers on a double circuit, 230-kv line from Hillsboro to North Branch, N. J. Length of the line will be approximately 11 miles.

Said to be the first application of free piston gasifiers to pipeline pumping, the Iraq Petroleum Company, Ltd, has placed an order with National Free Piston Power, a subsidiary of the Hawker Siddeley Group, for a 3000 hp free-piston gasifier turbo-pumping unit for erection on its pipeline in Syria.

Super insulations said to be up to 26 times more efficient than standard vacuum insulations, and capable of holding liquid oxygen for indefinite periods are now in use by Linde Company. The new insulations are seen as a major break-through in the field of cryogenic engineering.

Union Carbide Olefins Co has developed a robot coal miner which consists of a mining machine run remotely by one man at an electronic control center. It penetrates high-wall coal to a depth of at least 1000 ft. The machine has sensing elements which return electronic signal to operator telling whether the machine is heading properly into the coal. Prototype advanced a mining entry at more than 100 ft an hour.

First magnetic drives to be used in a feed pump installation in this country will drive six De Laval boiler feed pumps at the expanding Silas C. McMeekin Station of South Carolina Electric & Gas Co. The pumps are 3-stage, double-case, high pressure barrel type units. Each will deliver 1138 gpm of 341 F boiler feed water at 2793 psig discharge pressure against a 6885 TDH. The magnetic drives were built by Electric Machinery Manufacturing Co.

Graver Tank & Mfg Co has been awarded a contract to build all the storage tanks for the largest refinery in Norway, now being constructed on the Oslo Fjord, 50 miles south of the capital city, by an affiliate of Standard Oil Co (New Jersey). Graver will build 62 tanks, including four spheres, 33 fixed roof tanks and 25 floating roof tanks with a capacity of 2,000,000 tons of crude oil and petroleum products.

Long Island Lighting Co reports that Unit No. 3 at its Port Jefferson plant is on the line. Capable of generating 185,000 kw, the $26,000,000 plant addition raises the station's total net capacity to 290,000 kw. Cost of the total of four units planned for the station excluding land, transformers, switchyards and other related machinery is reported to be about $75,500,000.

Largest gasholder in the nation to be built since 1951 is now well under construction at east Long Beach for the City of Long Beach Gas Dept. The Wiggins gasholder has a diameter of 214 ft, is 173 ft 10 in. high, has 5,000,000 cu ft. It is part of the complete facilities of Compressor Plant No. 6.

S. Morgan Smith Co board of directors approved a plan subject to approval by its stockholders whereby Allis-Chalmers Mfg Co would acquire assets of the Smith Co in exchange for Allis-Chalmers common stock. It was hoped the plan would be in effect by the beginning of this year.

Miami Beach has recognized the value of polyvinyl chloride material as an important aid in the fight against corrosion. The city's latest electrical code specifies that rigid, unplasticized polyvinyl chloride pipe, Schedule 40, should be used in electrical installations where corrosion is a problem. A bonding conductor is specified for circuits above the signal and telephone voltage range. This provides a continuous bond between all metallic boxes, panels and fittings.

Westinghouse announced advanced development of an ultrasonic seam welder that can weld sheets of dissimilar metals continuously. Sheets of the metal to be welded are passed between two wheels vibrating at 20

kc. Periphery of the wheels presses against the metals on opposite sides of the sheets, breaking up the oxide coating on the metal surfaces and by a kneading action welding the metal lattices on the surfaces of the metals. No electric current is passed through the spot being welded, although the ultrasonic seam weld is similar to that of an electric weld. In contrast to cold welding, this new method does not require large deformation of the metal pieces being joined.

POWER IN '58: Edison Electric Institute's 24th semi-annual electric power survey indicates that America's electric power industry would reach a total generating capability of 146,000,000 kw for 1958, an increase of 12 per cent over 1957.

Total capacity addition installed and scheduled for 1958 will be about 15,000,000 kw, almost double that put into operation in 1957 and exceeding the previous high record of 1955 by 3,000,000 kw.

The survey shows that atomic-electric power projects, still largely developmental, are contributing some 71,000 kw to the national power supply. Other projects under construction or contract but not yet in operation will bring in approximately 850,000 kw more by 1962. Another three-quarters of a million kw of atomic-electric capacity still is in the planning stage.

Total generating capability of U. S. power systems now forecast for the end of 1961 is 180,000,000 kw, representing an average annual increase from the end of 1956 of 8 per cent. Power plant projects to provide this increase are now definitely scheduled.

NEW EDUCATIONAL FUND, from the Woman's Auxiliary of ASME, is to be known as the Marjorie Roy Rothermel Memorial Scholarship Fund. It provides for at least one scholarship of $750 to be awarded annually.

A candidate must be a man or a woman citizen of the U. S. A., who is in his senior year in Mechanical Engineering or who has already received his bachelor's degree in M.E. in an accredited college or university in the U. S., and who desires to continue his study for an advanced degree in engineering.

NEXT APRIL, Philadelphia's water works department — 4th largest in the nation — will swing over to a fully integrated electronic load control system, the closest step yet toward complete automation in the water works industry.

Thanks to the wonders of electronics, telemetering and microwave transmission, all vital operating data from over the 12-district system will be immediately available to an operator at the central load control center in downtown Philadelphia. Through a parallel supervisory control system, the operator will have finger-tip control over all major pumps and valves in the distribution network.

MARKET STUDY of the reinforced plastics industry for 1958 shows record sales of 185,000,000 lb. Boats, construction, consumer products, transportation, aircraft and missiles account for 76 per cent of the total. This represents a 10 per cent increase over the 168,000,000 lb reported in 1957.

The 14th annual conference of the Reinforced Plastics Division of the Society of the Plastics Industry will be held February 3, 4 and 5 at the Edgewater Beach Hotel in Chicago.

ELECTRICITY will begin to flow under the English Channel between France and England in time to meet the winter peak of 1960–61. This project, long under study so that the power grids of the two nations can be connected, is now in the engineering stage. François M. Cahen and Roger A. Tellier, of Electricité de France, have described the work in a paper presented at a recent AIEE meeting.

The cables will be laid between Dugness on the English Coast and Le Portel on the French Coast, a distance of some 32 miles and will connect the British 275-kv and the French 225-kv systems, so that both countries can exchange power.

NEWS ABOUT PEOPLE: M. J. Goglia, formerly professor at Georgia Institute of Technology, is now Dean of the College of Engineering, University of Notre Dame.

Elected to lead the American Academy of Sanitary Engineers for 1959 are: Thomas R. Camp of Camp, Dresser & McKee, Boston, Mass., chairman; R. E. Lawrence of Black & Veatch, Kansas City, Mo., vice-chairman; and R. S. Rankin, Stamford, Conn., treasurer.

Richard M. Bush has been appointed a senior consultant on the Washington, D. C., staff of Ebasco Services. Prior to joining Ebasco, Bush spent 16 years with the U. S. Army Corps of Engineers, serving in Washington as Chief of its Power Branch since 1955. He has had 37 years experience in the electric power field.

Robert R. Wagstaff, chief engineer, United Engineers Constructors, has been elevated by AIEE to the grade of Fellow, "for his contributions to design and execution of large power projects."

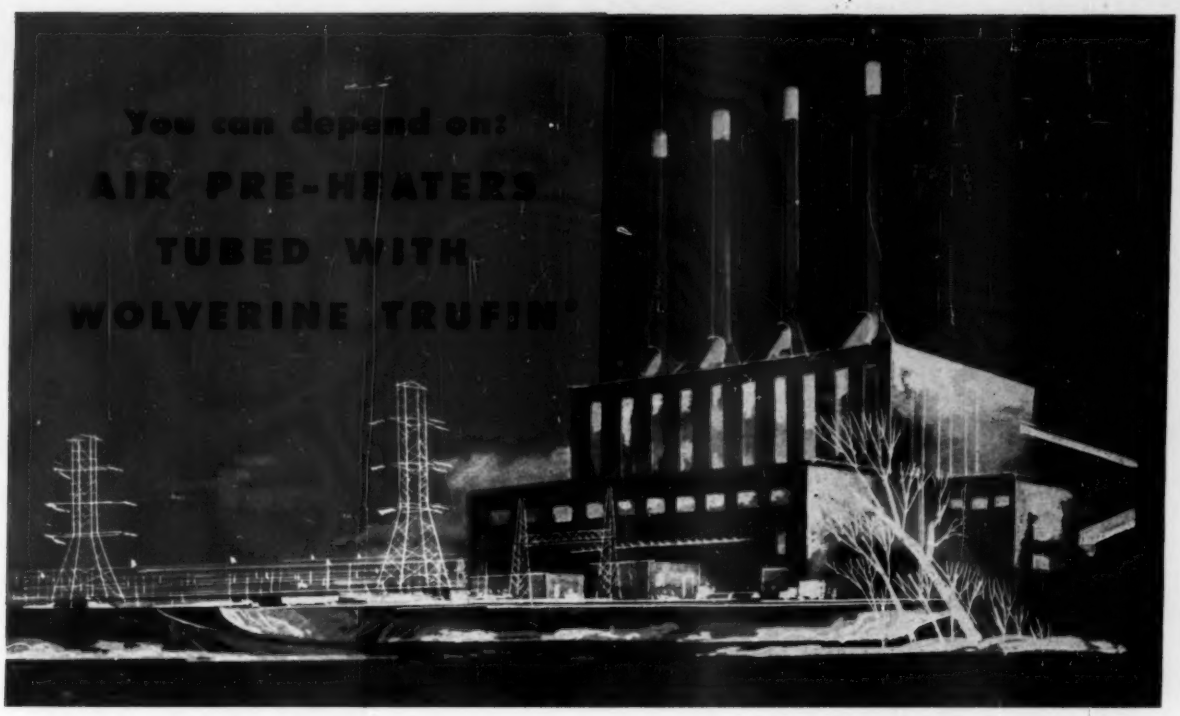
Ralph E. Hall, pioneer industrial water consultant, founder and immediate past director of Hall Laboratories, has had a suite of offices dedicated in his honor at the new headquarters building of the American Chemical Society in Washington, D. C.

WATER SHORTAGE is a problem that haunts many an engineer and industrialist. Fred A. Loebel, president of Cleaver-Brooks Special Products, recently estimated that consumption of water in the U. S. alone will surpass 500 billion gallons daily by 1978. Water consumption for domestic and industrial uses in the U. S. today averages between 250 billion and 265 billion gallons daily, according to government estimates.

Loebel thinks that continuing research and development of distillation equipment may drive costs of converting sea water to potable water to perhaps 70 cents a thousand gallons in the near future. It can now be done for around $1 a thousand gallons.

AIR AND WATER Pollution Abatement Conference, held by the Manufacturing Chemists' Association, is scheduled for March 17–18, at the Netherlands Hilton Hotel, Cincinnati.

Industrial power system requirements are the theme of a 2-day institute to be held on the 29th and 30th of this month in Madison, Wis., by the University of Wisconsin Extension Division in coöperation with the College of Engineering.

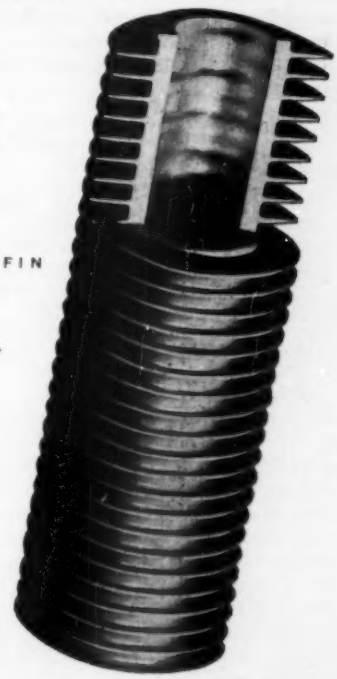


In many modern plants, engineers are gaining greater efficiency by specifying integrally finned Wolverine Trufin for use in combustion air pre-heaters.

The pre-heaters, currently going into a large power plant, are tubed with aluminum Trufin Type H/A. This tube saves weight—slashes costs. High-finned Trufin is also available in copper alloys and in a bimetallic form — an inner tube of copper bonded to an outer finned tube of aluminum.

Wolverine Trufin Type H/A has an outside to inside surface ratio of approximately 8:1. In this particular case, with pure condensing steam inside the tube, air is raised from 80°F. to 180°F. prior to entering the stack heaters.

If your company is contemplating the construction of a new power plant—or is expanding or modernizing—don't finalize pre-heater design until you get complete information about Wolverine Trufin and its benefits. Ask for the services of a Wolverine Technical Representative and write, too, for a free copy of the Trufin Catalog.



WOLVERINE TRUFIN
TYPE H/A

Wolverine Trufin is available in Canada through the Unifin Tube Division, London, Ontario.

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WHAT THEY TELL US

▶ **CRACKED BOILER DRUMS** and how to repair them, fast, was a subject treated in our November issue by John S. Cole (pages 80–81). Cole's experience touched off a responsive chord in Ira A. Butcher, an engineer in Cincinnati. Butcher tells us that:

> Many years ago, a 150-hp Scotch marine 150-psi boiler developed a cracked ligament in the rear tube sheet, the crack extending through the sheet. Tubes were removed from each side of the cracked ligament and were veed out with a chisel and hammer, then welded shut with a d-c arc welder, using plain welding rods, no other rods being available. The weld promptly broke as it cooled. The welding was done with a cold sheet.
>
> The crack was again veed out and welded a little bit at a time, with plenty of cooling time between each bit of welding. Each welding operation was wired brushed, as well as thoroughly cooled, before starting the next operation. The tube holes were cleaned out and new tubes were installed. No further trouble was experienced.

▶ **JACK MENSING,** of Automatic Electric Co's public relations department, liked our article (Nov issue, pages 64–65) on the power engineering aspects of his company's big new plant at Northlake, near Chicago. But . . .

> There are three minor corrections which we feel should be brought to the attention of your readers.
>
> First of all, steam capacity of the plant is 122,000 lb per hr, rather than 120,000, with three boilers of 50,000, 22,000 and 50,000 lb per hr capability. Second, the water from our wells has a hardness of 18 grains rather than the 15 grains stated.
>
> Third, the steam-turbine-driven, synchro-start generator in the power house is rated at 187.5 kw rather than the 150-kw figure mentioned.

▶ **HRT BOILER** welding repair involving a hand-hole plate was discussed by K. D. Cilley in our September issue, page 98. Following the argument closely, L. E. Gile of Kansas City, Mo., has felt constrained to tell us that . . .

> In my studies and experiences, I've never heard of a hand-hole plate in an HRT boiler. The plate Mr. Cilley speaks of would have to be in the fire side of the boiler, and this could not be. . . . If there is such a boiler, I would appreciate learning of its location.

In answer to this, Cilley explains:

> Back a number of years ago, it was not only customary but in some states mandatory that a hand-hole opening be installed below the tubes in the rear head of a horizontal return tubular boiler. Since oil and gas have now become more popular, the rear head hand-hole opening has in many installations been eliminated.
>
> To be more specific, I shall take a direct quote from the 1921 issue of Steam Boiler Rules, Commonwealth of Massachusetts, page 129, section 62: "A hand hole shall be located in the rear head of a horizontal return tubular, below the tubes, except one which has a manhole in the front head, below the tubes."
>
> Although the boiler referred to was 90 in. in diam, and contained a manhole at the front below the tubes, it also contained a hand hole at the rear to permit access for inspection as well as cleaning.
>
> This type of construction was common practice during the period of coal burning and is still practiced when desired by a customer because of an unusual water condition or otherwise. Present-day practice, where such installations exist, is to insulate the stud, nut and yoke from the products of combustion with a suitable material, to prevent overheating or burning of the parts exposed to the products of combustion.

▶ **OUR SCOOP** on Versene, the revolutionary new boiler scale-removal method (November issue, pages 61–63), has drawn a barrage of comment from all parts of the country. Typical are these:

> You and your staff have done an outstanding job on bringing to the engineering public the story of Dow's new development, Versene 100. — R. G. Wickert, engineering department, Armstrong Cork Co.
>
> I read the article on boiler scale removal process and was very impressed . . . I would appreciate all available materials. — Bob Johnson, chief engineer, Carnation Co, Los Angeles.
>
> The article by Mr. Alexander was one of the best I've ever read. Your magazine is to be complimented on its up-to-date coverage of such an innovation. — James Hale, Jr, power superintendent, Colgate Palmolive Co, Clarksville, Ind.
>
> Have read with keen interest the article, Three Years' Field Testing Proves New Scale-Removal Method. As offered, may we please have more information concerning this technique? — C. A. Stang, plant engineer, Baldwin-Lima-Hamilton Corp, Lima, Ohio.
>
> I would certainly appreciate receiving a half dozen tear sheets of your article . . . We have been doing similar work in a boiler plant here at Los Alamos and are very interested in . . . comparative studies. — Richard C. Crook, chief of utilities and engineering, The Zia Co, Los Alamos, N. M.
>
> It was with great interest that I read your article . . . Only two weeks ago we completed a month-long period of boiler overhaul. During this time we chemically and mechanically cleaned four 600-psig boilers at considerable cost as well as lost operating time. Our troublesome boiler scale was composed of hard organic scale as well as the usual boiler water inorganic salts . . . We hope to be prepared for a quicker, less expensive cleaning in case it is needed. Any information on chemical cleaning of boilers that you can supply us with will be greatly appreciated. — Herman L. Davis, process engineer, Texas Butadiene & Chemical Corp, Channelview, Texas.
>
> Your coverage of scale removal by Dow Chemical's Versene was excellent. — C. B. Breaux, technical engineer, The Bird-Archer Co, Philadelphia.

▶ **CHESTER EARLE's** report on Cigré's meeting in Paris last summer (August issue) has won a wide circle of readers. L. I. Komives, U. S. representative to Study Committee No. 2, High Tension Insulated Cables, Cigré, comments:

> . . . It contains a good, over-all picture of all the sessions.

▶ **REMINDER** to remind you of that useful reference tool — POWER ENGINEERING'S annual index — comes from Kenneth Dowell, a consulting engineer in Minneapolis. He writes:

> We would like to know if you publish an index to your magazine. Several times the occasion has arisen to refer to an article that has appeared, only to find that we cannot locate the article again.

Yes, we do publish an annual index of editorial material for the year. It's always bound into the December issue, just ahead of the back cover. To see what it can do for you — turn to your December, 1958 issue of POWER ENGINEERING, page 129.

Trapping Standardization

. . . steam trap standardization plus standardized hook-ups spell lower maintenance costs

An important weapon in the fight against rising maintenance costs is standardization. It can reduce the variety of maintenance problems and simplify those which remain.

Since we specialize in steam traps we'd like to offer some suggestions for a trapping standardization program. Such a program involves standardization on one make of trap and standardization of hook-ups.

Trap Standardization

The advantages of standardizing on a single make of trap are important and can make a big difference in the cost and ease of repairs because—

1. You can carry a more complete stock of repair parts with a smaller inventory.

2. Maintenance personnel has the opportunity to become expert on one make rather than be "jacks of all traps."

3. As an exclusive user of one make of traps you become a preferred customer of your trap representative and can be sure of getting the best possible service.

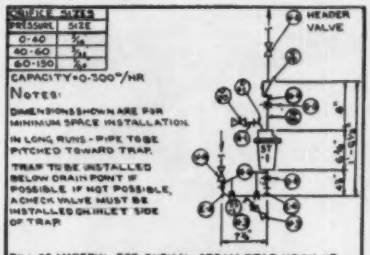
4. You can enjoy the advantages of standardized hook-ups.

Standardized Hook-ups

Standardized hook-ups facilitate and reduce the cost of both original installation and maintenance. By adopting standards for the dimensions of all fittings, including nipples, each hook-up for a given size of trap is identical and can be fabricated in the pipe shop.

Unions should be used so that when a trap needs repair, the unions can be uncoupled, the trap lifted from the line and a spare carrying identical length nipples and half unions slipped into place. In as little as a minute or two a faulty trap can be replaced. The faulty trap can go back to the storeroom for repair when convenient and then be put into stock as a spare.

Figure 1 shows a typical standardized hook-up used by a major chemical manufacturer. Note how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40-60
60-150
CAPACITY=0-500#/HR
NOTES:
DIMENSIONS SHOWN ARE FOR MINIMUM SPACE INSTALLATION
IN LONG RUNS - PIPE TO BE PITCHED TOWARD TRAP.
TRAP TO BE INSTALLED BELOW DRAIN POINT IF POSSIBLE. IF NOT POSSIBLE, A CHECK VALVE MUST BE INSTALLED ON INLET SIDE OF TRAP.
HEADER VALVE
BILL OF MATERIAL FOR TYPICAL STEAM TRAP HOOK-UP
MARK
DESCRIPTION
ST-1
STEAM TRAP - ARMSTRONG #811
S-1
STRAINER - 250# W.S.P. -
V-4
GATE VALVE - SCRD - 200# W.S.P. -
V-20
GLOBE VALVE - SCRD - 200# W.S.P.
V-3
GATE VALVE - SCRD - 200# W.S.P. -
V-19
CHECK VALVE - SCRD - 200# W.S.P. -
E-4
90° SCRD ELL - 2000#
E-41
90° STREET ELL - 3000# -
U-4
UNION - 2000#
N-1
SHORT NIPPLE - SCH 80 - SEAMLESS ASTM A-53
N-3
SHORT NIPPLE - SCH 80 - SEAMLESS ASTM A-53
N-4
SHORT NIPPLE - SCH 80 - SEAMLESS ASTM A-53
N-4/4
4" LG NIPPLE - SCH 80 - SEAMLESS ASTM A-53

Fig. 1—Typical standardized installation hook-up used by a leading chemical manufacturer.

the hook-up provides the following advantages:

1. Test valve in trap cap permits fast, easy checking of trap operation.
2. Strainer ahead of trap protects it against dirt and scale.
3. Blowdown valve in strainer provides easy cleaning.
4. Check valve in discharge line isolates trap when test valve is opened.
5. Shut-off valves and unions ahead of and following trap permit removal of entire trap from line.

Fig. 2—Armstrong traps have only two moving parts—the lever assembly and the bucket. Nothing much to go wrong here.

Another important consideration for getting the most from a standardization program is accessibility of the traps. Insofar as is possible, traps should be located so that they are convenient for inspection. The easier it is to locate and get at a trap, the less likelihood that it will be overlooked.

What Make of Trap? (This is the Commercial)

Obviously, a trap standardization program shows the best results when the make of trap selected is the one that gives the best service. Naturally, we think the make should be Armstrong and fortunately a lot of trap users agree. Here are some of the advantages of standardizing on Armstrong that have been pointed out by these users:

1. *Armstrong traps work.* They don't leak steam and they do discharge condensate and air as fast as they reach the trap. And they work with any return system.

2. *Armstrong traps aren't "prima donnas."* They need no special care or coddling. Valve and seat are hardened chrome steel. Lever assembly and bucket are stainless steel and these are the only moving parts.

3. *Armstrong traps aren't "orphans."* You can *always* get parts and service from nearby Factory Representatives and stocking distributors.

4. *Armstrong traps are guaranteed.* If you're not *completely* satisfied you can return the traps for refund of purchase price.

More Information

The 44-page Steam Trap Book (free on request) gives a lot more facts on trap selection and installation. Call your local Armstrong Representative or write **Armstrong Machine Works, 8101 Maple St., Three Rivers, Michigan.**

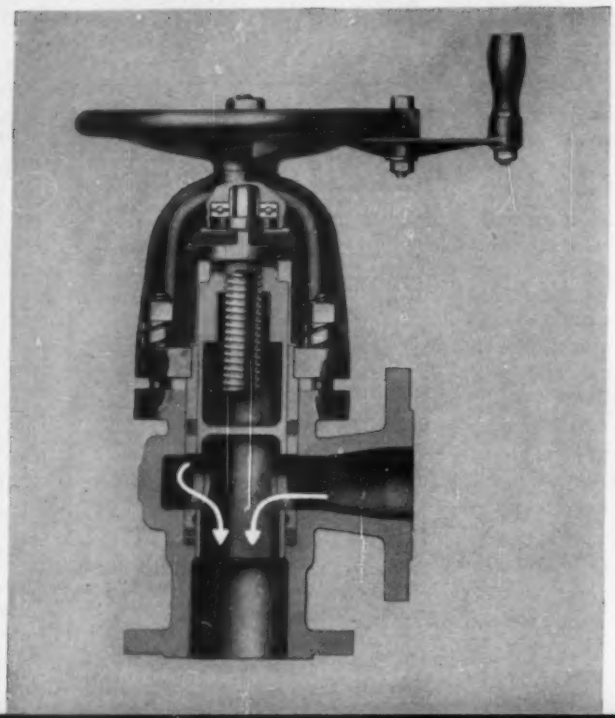
ARMSTRONG STEAM TRAPS

For more data circle 505 on Post Card

These YARWAY VALVE DESIGNS

YARWAY SEATLESS

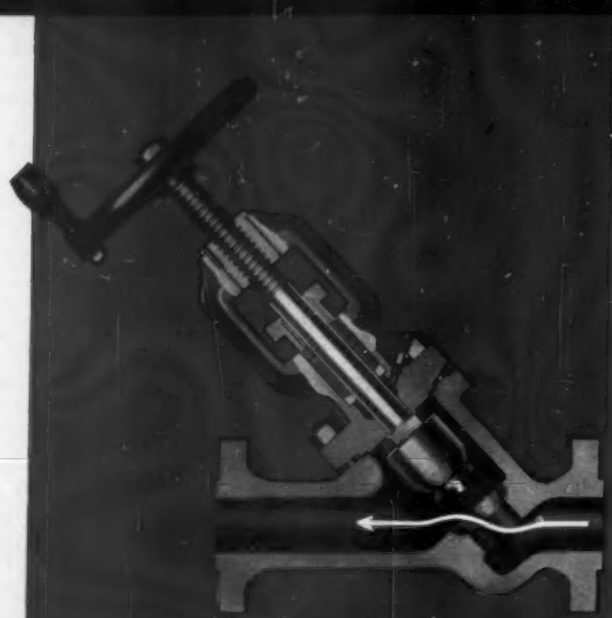
Features balanced nitralloy hollow plunger that seals line drop-tight, yet permits free, unobstructed flow in blow-down. Other features —laminated packing, alemite lubrication, ball thrust bearings. USED SUCCESSFULLY IN OVER 15,000 BOILER PLANTS.



FOR LOW and MEDIUM PRESSURES

YARWAY HARD-SEAT

Features tough, stellite-faced and ground disc and seat ring, mated to provide smooth long-wearing surfaces. Stream-line flow. Alemite lubrication. MORE THAN 4 OUT OF 5 HIGH PRESSURE BOILER PLANTS USE YARWAY BLOW-OFF VALVES.



FOR HIGHER PRESSURES

USED IN OVER 15,000 BOILER PLANTS

serve every boiler blow-down need

■ Whatever your *pressure* requirement, whatever your *piping* requirement—there's a Yarway Blow-Off Valve to exactly meet your needs.

Popular Yarway *seatless* design keeps blow-down lines drop-tight in low and medium pressure ranges. Sturdy Yarway *stellite seat and disc* design protects higher pressures.

All Yarway Blow-Off Valves are strong, rugged valves, built to withstand the punishment of regular or emergency blowing-down under full boiler pressure, and are available in metals that stand up under acid washing of boilers.

Write for new Yarway Blow-Off Valve Bulletins—B-426 (pressures to 400 psi) or B-434 (pressures to 2500 psi).

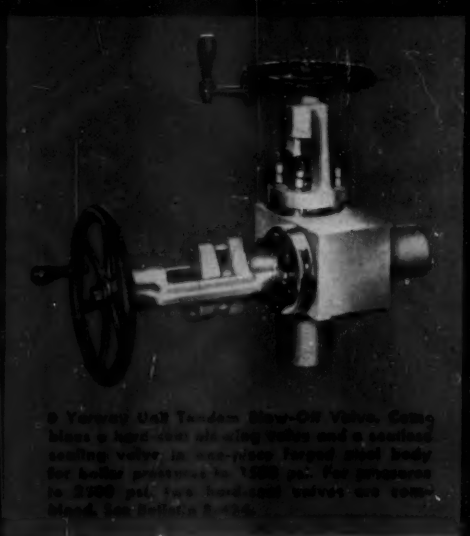
• Yarway Type B Seatless Blow-Off Valve, iron body for boiler pressures to 200 psi, steel bodies, for pressures to 400 psi. Angle valve shown, straightway available. Flanged connections. See Bulletin B-426.

• Yarway Type B Seatless Tandem Blow-Off Valve combining two angle valves. Other combinations available. Iron bodies for boiler pressures to 200 psi, steel bodies for pressures to 400 psi. See Bulletin B-426.

• Yarway Type C Seatless Tandem Blow-Off Valve combining angle and straightway valves. Other combinations available. Flanged or welding connections available. For boiler pressures to 600 psi. NOTE: When used in tandem with a Yarway Hard-Seat Valve, Type C Seatless may be used to 1500 psi. See Bulletin B-434.

• Yarway Hard-Seat Blow-Off Valve for pressures to 2500 psi. Straightway valve shown. Angle available. Welded (shown) or flanged connections. See Bulletin B-434.

• Yarway Hard-Seat—Seatless Balted Tandem Blow-Off Valve. Hard-Seat is the blowing valve, seatless is the seating valve. Available in any combination of connections. For pressures to 1500 psi, Hard seat-hard seat tandems for pressures to 2500 psi. See Bulletin B-434.



• Yarway Unit Tandem Blow-Off Valve. Combines a hard-seat air-operated valve and a seatless seating valve in one-piece forged steel body for boiler pressures to 1500 psi. For pressures to 2500 psi, two hand-operated valves are combined. See Bulletin B-434.

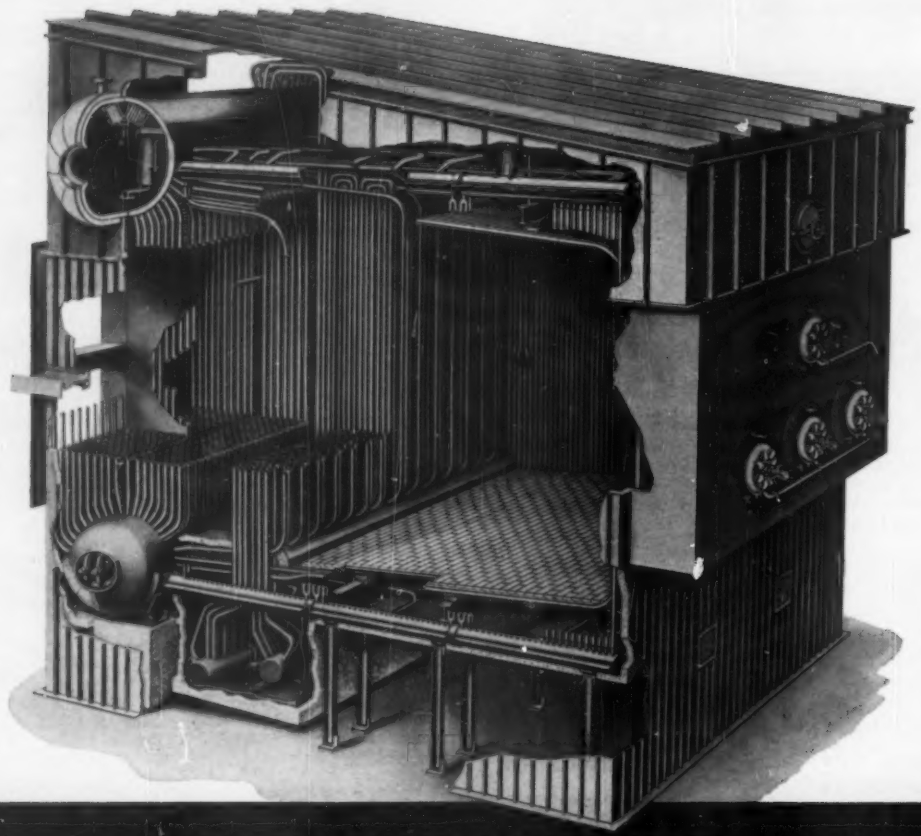
LET YARWAY HELP SOLVE YOUR BOILER BLOW-DOWN PROBLEMS!

YARNALL-WARING COMPANY
100 Mermaid Avenue, Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES

YARWAY

blow-off valves

Designed For Tomorrow's New, Economical



HERE ARE 8 WAYS IN WHICH THE PFI BOILER CAN BE OF BENEFIT TO YOU:

1. It requires a minimum amount of space for a given power output.
2. The pressurized furnace design assures economy by eliminating the induced draft fan and air infiltration. This means savings in cost of fans, fuel, and operating power.
3. Pre-assembly of many of the components of the PFI Boiler is controlled in B&W shops, resulting in a reduction of the time and manpower required for field erection.
4. The PFI is designed to burn oil, gas, or a combination of the two. When it is equipped with a dual-fuel burner, it allows you to take advantage of favorable market conditions.
5. Cyclone Steam Separators ensure adequate water circulation which protects boiler tubes from overheating, even with wide and frequent changes in load. They also give you clean, dry steam at all designed ratings with high boiler water concentrations.
6. The drainable superheater design assures quick, safe start-up and ease of storage.
7. Water-Cooled Burner Throat eliminates troublesome maintenance, costly repairs.
8. All-welded Membrane Wall contributes to high efficiency and reduces insulation requirements.

Plants Power For Industry

New B&W PFI Oil-Gas Burning Unit Provides Maximum Output in Minimum Space

Here's an answer to industry's need for an economical, dependable steam supply. The new B&W Integral-Furnace Boiler produces high-quality, dependable steam economically at all ratings. Aptly named the PFI, the "Power for Industry" Boiler is compact, easy to install, quick to meet rapid and wide load swings. The new boiler gives long, sustained operation, requires little attention and is readily accessible for inspection, cleaning and maintenance.

All responsibility for your complete delivered and erected unit is accepted by one experienced, dependable source which in the past 25 years alone has placed over 4,000 Integral-Furnace Boilers in service. Behind *every* B&W Boiler is nearly a century of leadership in steam generation. A national network of B&W plants and engineering facilities means that the special skills of B&W engineers are always quickly available to you for service and assistance. The Babcock & Wilcox Company, Boiler Division, 161 East 42nd Street, New York 17, N. Y.

For further information about the B&W PFI Boiler, write for Bulletin G-94.

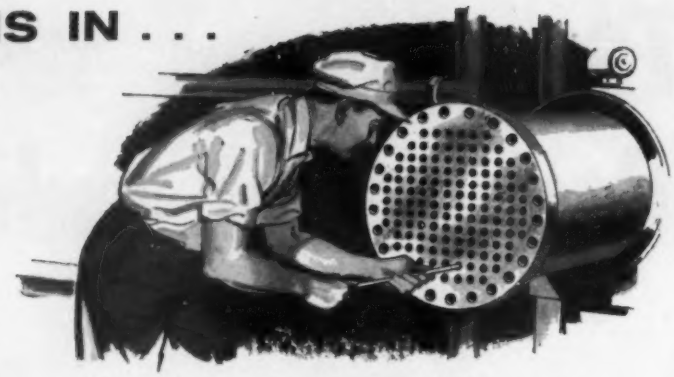
BABCOCK & WILCOX

BOILER DIVISION

G-899

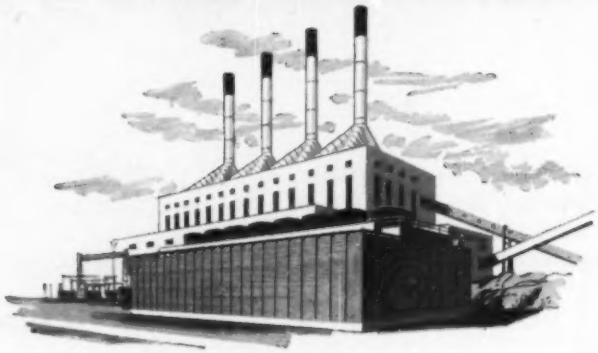
For more data circle 507 on Post Card

WATER PROBLEMS IN . . .



heat exchangers?

pipe lines?



cooling towers?

CALGON HAS THE ANSWER

Corrosion and other water damage to key points in cooling and service water systems can tie up an entire plant. Costly equipment can be damaged beyond repair. Replacement costs and the losses caused by unscheduled outages far outweigh the modest cost of adequate protection.

Call on Calgon Engineering Service to insure protection of the entire system. From cooling towers on through, the Calgon engineer can save you money and time. Experience with every type of water problem in all parts of the country, backed by complete laboratory facilities, is at your service.

Corrosion control with Calgon* is only one of the many services available. A letter or phone call will bring a man with the water problem answers to work for you.

*Calgon is the Registered Trademark of Calgon Company for its sodium phosphate glass (sodium hexametaphosphate) products. The use of polyphosphates for the prevention of corrosion is covered by U. S. Patent 2,337,856.

CALGON COMPANY

DIVISION OF **HAGAN** CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY, HALL LABORATORIES
IN CANADA: HAGAN CORPORATION (CANADA) LIMITED, TORONTO

For more data circle 508 on Post Card

"Buffalo" Type
"BLH" Fan

HIGH EFFICIENCY OVER BROAD OPERATING RANGE PROBABLY YOUR BEST CHOICE FOR M. D. FANS

Does your mechanical draft installation require a fan that delivers peak-efficiency performance over a broad range? A fan that will give you this with the greatest possible long-range economy?

Then the "Buffalo" Type "BLH" is the fan you're looking for.

The "Buffalo" Type "BLH" Fan maintains a high mechanical efficiency over a very broad operating range with a peak efficiency of 86%. And it does this smoothly, quietly and most economically because of a number of important "Buffalo" design factors:

• Streamlined housing is uniquely engineered to provide smoothest air flow, highest possible static conversion and excellent pressure distribution at fan outlet.

• Minimizing turbulence are the smooth inlet bell, directional inlet vanes (standard, matching variable inlet vanes are optional) backward-curved blades, rotor flange curved to match inlet bell and the gradually divergent outlet. These features also result in extremely efficient performance and outstandingly stable operation from free delivery to shutoff.

• The 82 year old "Buffalo" reputation for rugged, dependable construction insures long, maintenance-free life.

If you're looking for this kind of efficiency and economy in a mechanical draft fan, call your nearby "Buffalo" engineering representative. Or write us for Bulletin FD-905.

BUFFALO FORGE COMPANY
Buffalo, N. Y.

Buffalo Pumps Division • Buffalo, N. Y.
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

VENTILATING • AIR CLEANING • AIR TEMPERING • INDUCED DRAFT • EXHAUSTING • FORCED DRAFT • COOLING • HEATING • PRESSURE BLOWING

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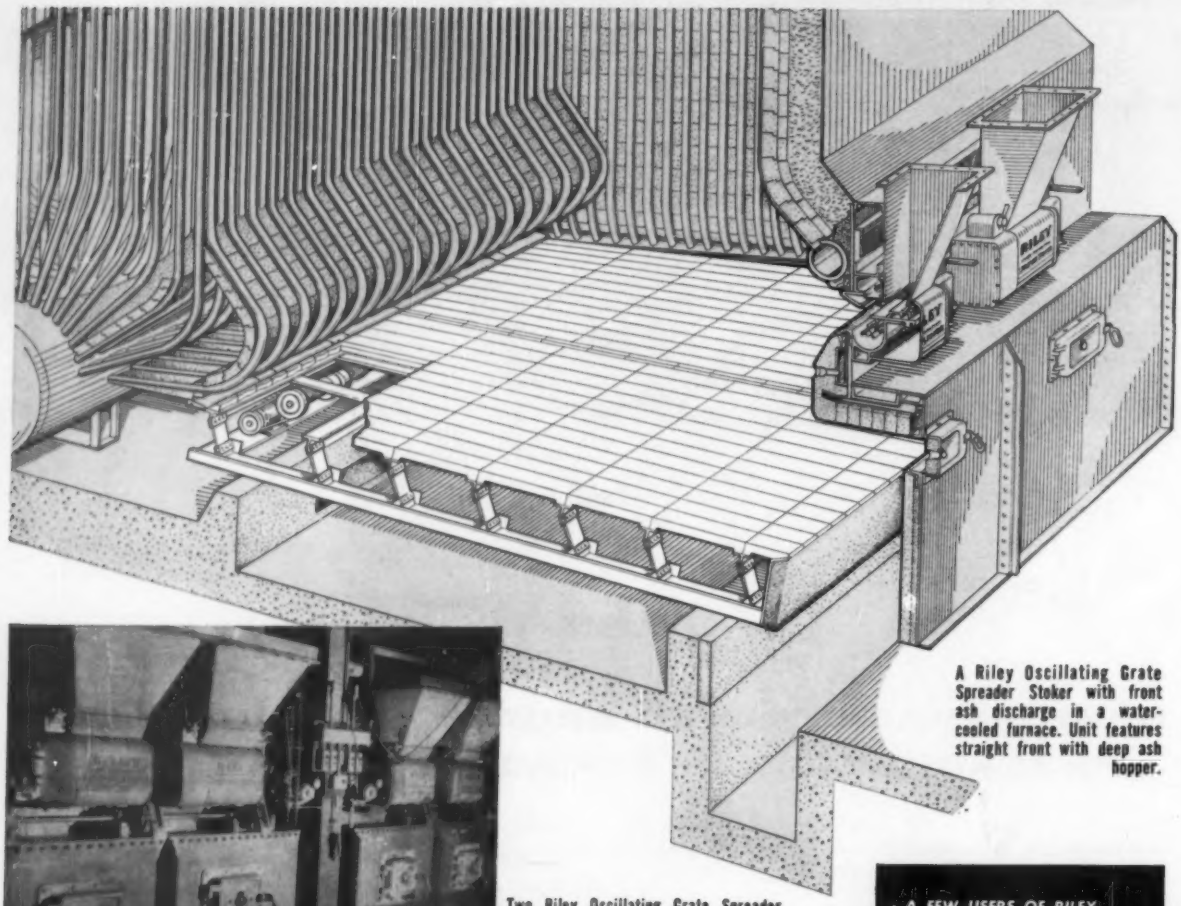
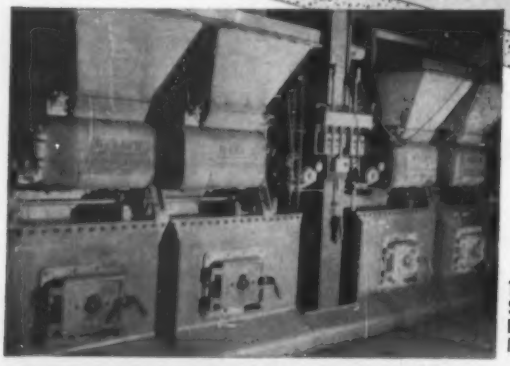
The NEW Self-Cleaning RILEY OSCILLATING GRATE

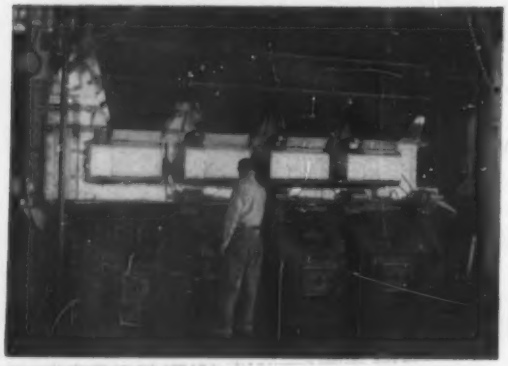
Efficiently Burns A Wide Range of Coals Under Boilers Having A Wide Range in Capacities



A Riley Oscillating Grate Spreader Stoker with front ash discharge in a water-cooled furnace. Unit features straight front with deep ash hopper.



Two Riley Oscillating Grate Spreader Stokers fire two 25,000 lbs per hour boiler units installed at prominent college located in western Massachusetts.



This Riley Oscillating Grate Spreader Stoker is installed under a 50,000 lbs per hour boiler unit at a southeastern Air Force Base.

A survey of your plant by a qualified consulting engineer could possibly show ways of making surprising savings in your power costs.

RILEY STOKER CORPORATION
WORCESTER, MASSACHUSETTS

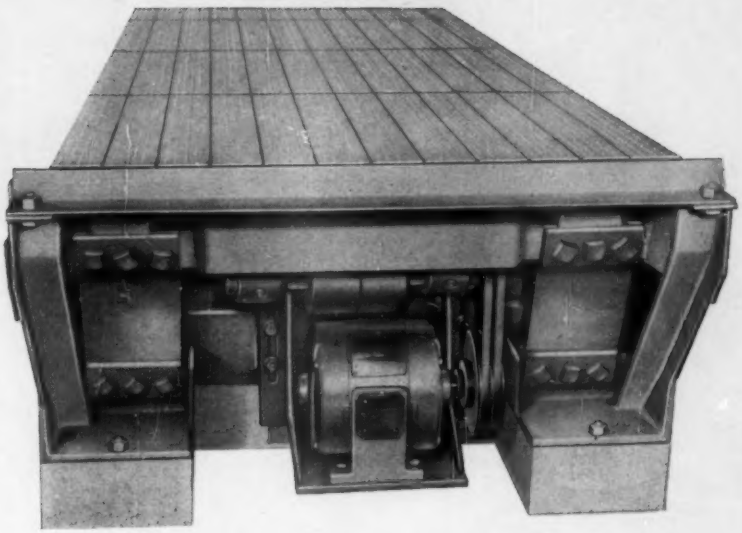
A FEW USERS OF RILEY OSCILLATING GRATE SPREADER STOKERS

St. Mary's Kraft Corp.
Elk Paper Mfg. Co.
Collins & Aikman Corp.
American Boxboard Co.
Mohawk Paper Mills
Chase Brass and Copper
Pittsburgh Plate Glass
E. I. duPont de Nemours
Andrews Air Force Base
U.S. Naval Air Station Brunswick, Me.
Clinchfield Coal Corp.

SPREADER STOKER

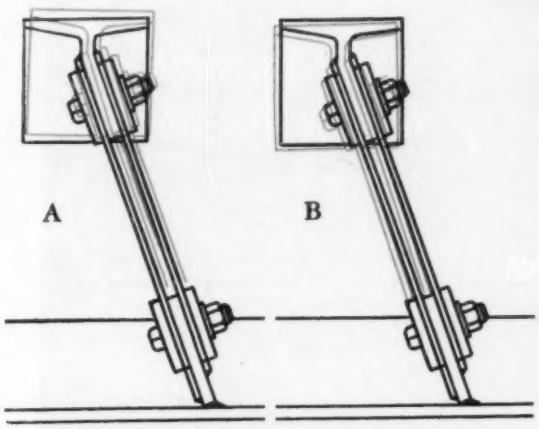
Adaptable To Any Furnace Depth and Width

Easily Installed At Low Cost For Either Front or Rear Ash Discharge.



Low Maintenance

The use of high heat-resistant alloys and adequate surface cooling gives long life to grate bars and seals. The only lubrication necessary is to the grate drive motor and to the feeders.



The amplitude of the flexure plates is exaggerated in this illustration to show positions of flexure plates when in high and forward position (A) and in the low and rear position (B). This amplitude of motion in actual oscillation of the grate is only about ⅛ of an inch.

Low Power Consumption

The oscillating drive mechanism employed with Riley Oscillating Grate Spreader Stokers is unusually simple in design and construction. One or more weights are eccentrically mounted on a single shaft supported by pillow block type bearings attached to the free moving cross-tee grid. The oscillating drive mechanism is belt driven by fractional horse power electric motor at approximately 1200 RPM. Oscillating motion of the slightly inclined grate surface moves the ash along the grate surface to the discharge end and into the ash pit. Depending upon the type of fuel and burning rates, the amplitude and frequency of oscillation is adjusted to discharge into the ash pit only ash and not burning fuel.

At full load oscillation of grate occurs at intervals of approximately 5 seconds every 10 minutes. Operation of the unit is governed by a timer control which determines the rate of fuel bed travel to suit load demand.

For complete details on this revolutionary stoker design contact a Riley Representative in any one of the following cities:

Charlotte, Chicago, Cincinnati, Cleveland, Detroit, Houston, Jacksonville, Kansas City, Los Angeles, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Salt Lake City, San Francisco, Seattle, St. Louis, St. Paul, Syracuse, Worcester.

RILEY

STEAM GENERATING & FUEL BURNING EQUIPMENT

For more data circle 510 on Post Card

Famous

SALK HALL

at the University of Pittsburgh to be serviced by Ric-wiL underground piping . . .

Salk Hall is where Dr. Jonas E. Salk and his staff are conducting their continuous virus studies. This ten-story building will eventually become a center for experimental medicine with additional space for research conducted by many faculty members.

Ric-wiL is proud to be a part of this great institution and has, since 1932, supplied the underground steam distribution lines. Over 10,000 feet of Ric-wiL serves an area more than a half-mile long and a half-mile wide.

Over 500 universities, colleges and schools are presently using Ric-wiL Piping Systems.

We invite your inquiry regarding the many types of Ric-wiL Systems available.

Salk Hall and campus photo courtesy of University of Pittsburgh.

Write, wire or phone for complete literature.

Quality Piping Systems . . .
. . . of Exceptionally High Thermal Efficiency

SINCE 1910

RIC-WIL INCORPORATED — PREFABRICATED INSULATED PIPING SYSTEMS

BARBERTON, OHIO

IN CANADA: THE RIC-WIL COMPANY OF CANADA LIMITED

See our catalog in Sweet's

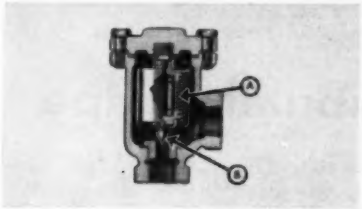
For more data circle 511 on Post Card

Full-range steam traps cut high cost of steam pressure variations

By John W. Ritter, Test Engineer
SARCO Company, Inc.

While boiler room economics dictate that boiler pressures remain constant, the equally sound economics of batch processing may decree that pressures at the equipment vary with the requirement of the process. The attempt to choose a steam trap that is all things to all conditions may result in installing traps that operate inefficiently at either extreme of their pressure range or that require adjustment every time the operations sheet calls for another pressure-temperature setting. Orifice traps represent a somewhat more rational approach to the problem, but often at the price of a continuous discharge of steam, particularly at the low pressures of start-up and shut down. Compromise, adjustment, and steam waste all spell inefficiency in the utilization of steam.

Production-Planned steam trapping, on the other hand, improves efficiency by the use of properly designed and installed thermostatic steam traps. Such traps employ the expansion and contraction of a thermostatic element to operate the discharge valve.

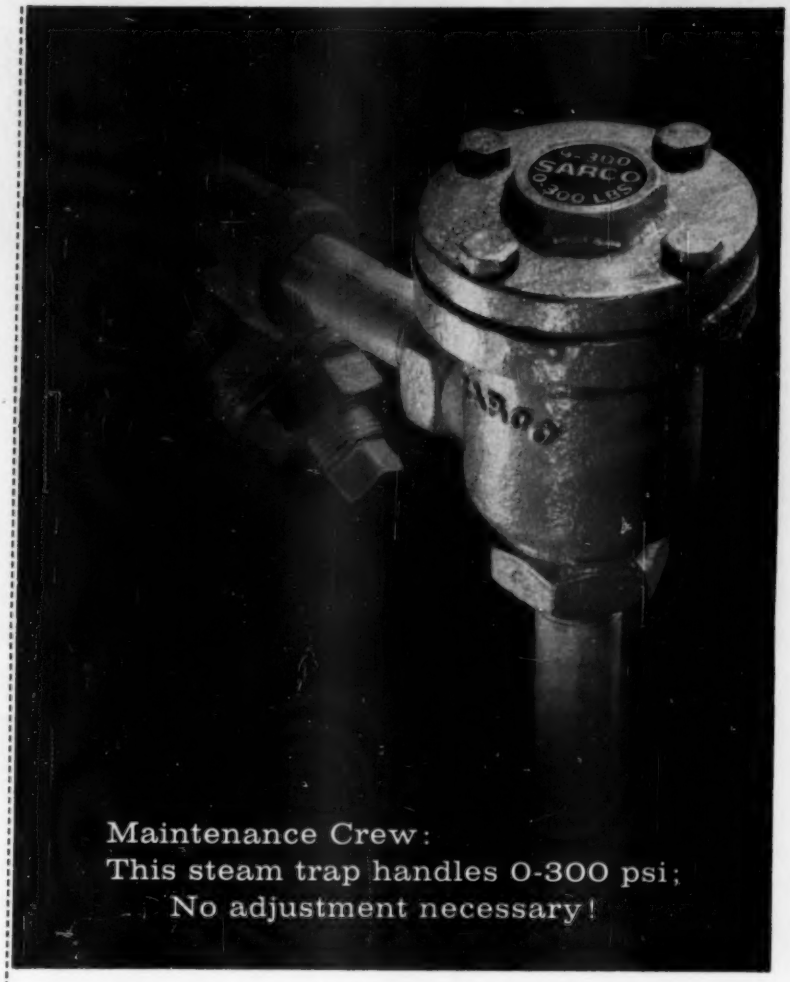


In Sarco Thermostatic Steam Trap, element (A) expands at steam temperature to close valve (B), contracts to permit discharge of condensate.

In the Sarco "Balanced Pressure" Thermostatic Steam Trap a volatile fluid is sealed inside a metal bellows that opens or closes the valve as it contracts or expands with condensate temperature. Near steam temperature, evaporation of the fluid creates an internal pressure greater than steam pressure in the trap body, and the expanding bellows seats the valve. When the condensate cools, the element contracts and opens the valve.

It is evident that at steam temperature pressure inside the element is higher than steam pressure, no matter how the latter may vary. Thus, the trap compensates automatically for variations in pressure.

58108



Sarco "Balanced Pressure" Thermostatic Steam Traps cut trap maintenance costs and simplify parts inventory. Why? Because the same bellows, head and seat handle steam pressures up to 300 psi – without any need of adjustment for variations in load or pressure.

Other advantages: unmatched capacity/cost ratio (1" size discharges 9,650 lbs/hr. at 10°F below steam temperature, 125 psi). This trap can't air-bind and, when installed with free discharge, can't freeze.

Long life and reliable performance are assured by an exclusive Sarco process for fabricating the one moving part – the thermostat – and by steam-testing of every single trap at maximum rated pressure.

Write for "Literature Kit 1A" today. And remember, Sarco can give you impartial advice on *Production-Planned* steam trapping because . . .

SARCO
COMPANY, INC.
635 Madison Ave., New York 22, N. Y.

Only Sarco makes all 5 types:
Thermostatic • Liquid Expansion • Float Thermostatic
Thermo-Dynamic • Bucket

STEAM TRAPS • TEMPERATURE CONTROLLERS • STRAINERS • HEATING SPECIALTIES

For more data circle 512 on Post Card

Dotted lines indicate magnetic fields. Color shading illustrates the resultant distribution of alternating current in round rod conductors. Mechanical force is developed as the centers of current try to move into the centers of their magnetic fields.

Low skin-effect ratio favors tubular shape

Skin effect becomes increasingly important in the medium and larger sizes of bus conductors carrying alternating current. It is the basic reason for using tubular conductors, quite apart from the structural advantages which they also possess. Tubular shapes (round or square) and paired channels have low skin-effect ratios, i.e., low effective resistance to alternating current.

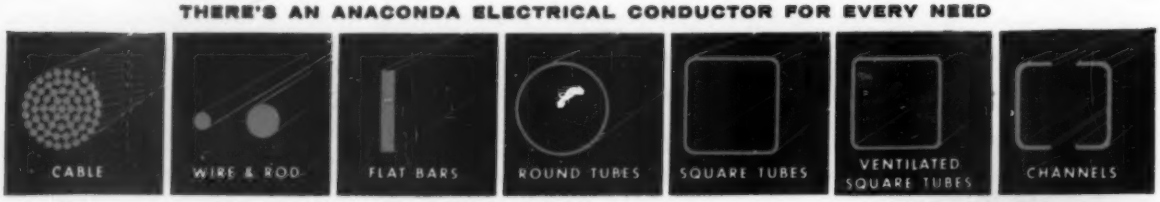
Skin effect is, essentially, the crowding of the main alternating current flowing in a conductor toward the outside surface by a contrary flow induced in the center of a solid conductor, a cable, or in the inner annular area of a tubular conductor by the constantly varying magnetic flux surrounding it.

Proximity effect is uneven distribution of an electrical current over the cross section of a conductor due to distortion of the surrounding magnetic field by the field or fields generated by current in neighboring conductors. The practical result of "proximity" is an increase in the apparent resistances of the conductors affected. Mechanical forces also are generated.

Field and current distribution problems are two of the many which complicate bus design. The Technical Department of The American Brass Company is always available to engineers for consultation in the selection of Bus Conductors for specific needs. See your Anaconda representative, or address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

ANACONDA® COPPER CONDUCTORS

THERE'S AN ANACONDA ELECTRICAL CONDUCTOR FOR EVERY NEED



For more data circle 513 on Post Card

HELPFUL BULLETINS

INSTRUMENTS AND CONTROLS

101 Draft and Draft Gages — The What, Where, How and Why of draft as it affects efficiency of combustion process, together with details on types of draft gages forms the subject matter of 20-pp Bulletin 58-S201. Tells what draft is, how it is measured, what the draft gage tells, and how to select a gage to suit requirements, as well as where to measure draft and pressure in a steam plant, where to connect and how to install draft gages. The Hays Corp.

102 Industrial Control — Eight-pp Bulletin 958 illustrates and describes a line of industrial control equipment, including push-button stations, speed-responsive switches, resistors, assembled controllers, contactors and relays, drum controllers, and others. The Euclid Electric & Mfg. Co.

103 For Centralized Control — Bulletin 106, 16 pp, illustrates and describes the design approach, materials, construction and modern facilities used in manufacturing a variety of centralized control and data presentation systems. Panellit, Inc.

104 Gage, Valve Selector — This slide rule selector is designed for easy selection of correct size and type of liquid level gages and valves. It condenses a wealth of specifications, sizes and other data in easy-to-use form. Gives size numbers, visible glass and center-to-center connections for the complete line of gages in all types and pressure groups. Jerguson Gage & Valve Co.

105 Diesel Engine Controls — Featured in 24-pp Bulletin B45–1 is a line of controls for diesel engines. Temperature and pressure control systems for diesel engines, safety devices, tachometers, control motors, valves, switches, relays, and related accessories are described. Minneapolis-Honeywell Regulator Co.

PUMPS, PUMPING

106 Centrifugal Pumps — Eight-pp Bulletin 720.4 describes single stage side suction centrifugal pumps with open impeller for a variety of industrial uses. Specifications, sectional view, dimensional chart, materials of construction and parts interchangeability charts, and performance curves are included. Goulds Pumps, Inc.

107 Double Suction Pumps — Six-pp Bulletin 251 features company's Type DMB and DB ball bearing, horizontal split case, double suction centrifugal pumps for general water service. Includes detailed specifications, sectional view, selection table, dimensions. Warren Pumps, Inc.

108 Screw Pumps — Six-pp Bulletin SI-6 outlines construction, operating characteristics, dimensions and capacities of internal gear and bearing screw pumps. Includes standard horizontal, vertical submerged sump type, vertical dry type hopper, and steam jacketed types, in capacities from 1 to 2000 gpm, discharging up to 1000 psi, for fluids, and semifluids. Sier-Bath Gear & Pump Co., Inc.

109 Fluid Power Equipment — Bulletin 10051-G, 12 pp, includes specifications, illustrations and descriptive matter on company's fluid power equipment. Covers variable delivery one- and two-way pumps; constant delivery duplex and automatic feed pumps; constant displacement, variable displacement, reversible motors; variable speed transmissions; standard and heavy-duty cylinders; presets, amplifiers, panels and servo valves for electrohydraulic systems. The Oil-gear Co.

110 Nuclear Pumps — This bulletin describes centrifugal pumps for all types of nuclear pumping applications. Three basic types are covered — liquid metal, liner-motor and mechanically-sealed pumps, with general description and capacity ratings. Byron Jackson Pumps, Inc.

BLOWERS

111 Blowers at Work — How units of company's California series of rotary positive pressure blowers and gas pumps are used to solve several air and gas handling problems is told in 8-pp Bulletin S-59G. Illustrated with photos and dimensioned drawing, bulletin shows a variety of applications. Also includes discussion of basic blower, its operation, construction, types of drive etc. A chart outlines performance examples of 20 blowers and pumps. Sutorbilt Corp.

112 Blower Units — This 16-pp bulletin covers an expanded line of medium pressure air conditioning units in sizes from 500 to 50,460 cu ft of air per minute, in vertical or horizontal models. Construction features and accessories are illustrated, and physical dimension charts and capacity tables included. M. Blazer & Son.

113 Multizone Units — Catalog 1635-B describes blowers for multizone central air conditioning systems. Comprehensive performance and application data are given, including construction details, dimensions and specifications. Sturtevant Div., Westinghouse Electric Corp.

VALVES, PIPE, FITTINGS

114 Valve Ordering Data — In these condensed catalog sections, 12 pp, are presented bronze, globe, angle, check, gate, radiator and specialty valves. Material is so listed that you can readily find pressure ratings, recommended uses, features, and roughing-in dimension for each valve in a wide range of sizes. Pages are arranged with low and standard pressure valves of each type together. Ohio Brass Co.

115 Solenoid Valves — Featured in this 8-pp bulletin are packless solenoid valves designed to permit more flow at any pressure up to maximum rated capacity. Specifications and performance charts are included, as well as flow patterns, dimensions, selection chart. C. A. Norgren Co.

116 Servo Valves — Catalog 220, 6 pp, describes flow-control servo valves available at maximum rated flows to 10 gpm at 1000 psi valve drop with operating supply pressures from 500 to 4500 psi. Detailed information is accompanied by curves on normal flow gain tolerance, load flow-pressure characteristics, typical frequency response and tolerance and nominal coil characteristics. A glossary of servo valve terms given. Moog Valve Co., Inc.

117 PVC Pipe, Fittings — This 12-pp bulletin contains latest technical information on polyvinyl chloride pipe and fittings, including advantages and properties, general characteristics and applications, physical properties, installation instructions, flow rate charts and complete specifications. Also included is a chemical resistance chart of various reagents and their effect. Mueller Brass Co.

118 Special Fixtures — Special purpose water faucets are illustrated and described in 64-pp Catalog 58SF. Designed to supplement company's general catalog, this booklet covers faucets for a wide range of applications, as well as a variety of interchangeable spouts, supply connections and related fittings. Special attention is given to faucets with integral vacuum breakers. Detailed dimensions and roughing-in data included. Chicago Faucet Co.

119 Stainless Steel Fittings — Dimensional data on stainless steel welding fittings and flanges manufactured by this company is contained in 54-pp Catalog TT 600. Updated technical data for allowable S-values, allowable working pressures of fittings, pressure-temperature rating of flanges and corrosion resistance are furnished. Applications for stainless steel piping, welding procedures are detailed, and principal users of stainless steel piping and welding fittings and flanges listed. Tube Turns, Div. Chemetron Corp.

120 Hydraulic Fittings — Divided into three sections covering self-flaring fittings, no-flare fittings and flare-type fittings, 28 pp Catalog 556 features a complete line of hydraulic tube and pipe fittings. Each section contains information on design and installation of particular type covered plus detailed dimensional and engineering specifications. Flodar Corp.

New and revised publications reviewed on these pages offer help on operating and maintenance problems. To order, use the handy Reader Service Cards provided on pages 105 and 106.

121 Stainless Steel Fittings — Comprehensive information on stainless steel fittings is given in this 86-pp loose-leaf, master reference volume. Presents a broad line of IPS and tube OD welding fittings, screwed and socket welding fittings and ASA, MSS and corrosion weight flanges. Technical section includes data on manufacturing standards, specifications, data on welding of stainless steel and corrosion resistance tables. Tab indexed for ready reference, book also contains part number and product index. Available to qualified power engineers, please state your job title when requesting this book. Ladish Co.

BOILERS, HEAT EXCHANGERS

122 Package Generator — This illustrated folder describes in detail features and advantages of company's line of pack-

age steam generators. Specifications are included. Cyclotherm Div., National-U.S. Radiator Corp.

123 Packaged Boilers — Specifications and descriptive data on rotary forced draft and pressure forced draft Webco-Ray boiler-burner units are described in this 8-pp bulletin. Advantages of three-pass boiler design are discussed in detail. Webco Boiler Co., Inc.

124 Heat Exchangers — Comprehensive information on heat exchangers and pressure vessels for process and power industries is presented in 16-pp Bulletin M581. Photos and diagrams illustrating basic types of heat exchangers and pressure vessels are included, as well as two charts — "Key to Heat Exchanger Types" and "Preliminary Setting Diagram". Southwestern Engineering Co.

125 Pipeline Aftercoolers — Eight-pp Bulletin 302.6K1, on pipeline aftercoolers, describes and illustrates their steel shell construction, removable corrosion-resistant tube bundle, counter current flow design, and centrifugal moisture separator. Specifications give details on 54 models with capacities for operating pressures to 125 psig for single- and two-stage compression. Ross Heat Exchanger Div., American-Standard.

BURNERS

126 Industrial Burners — Packaged burners for gas, oil or dual fuel, natural or induced draft, any type of boiler, are described in Folder 5807. Cutaways, diagrams and photos show how the integral air register improves combustion and reduces installation costs. Dimensions included. Iron Fireman Mfg. Co.

127 Automatic Fuel Burner — Eight-pp Reference Bulletin 430B describes features and advantages of company's automatic fuel burner. Design and construction details are illustrated and described. Peabody Engineering Corp.

128 Firing Systems — "On the Firing Line (Folder 5843) describes industrial packaged forced-draft firing systems for dual- or single-fuel firing of high or low pressure natural, LP or manufactured gas or Grades 2 through 6 oil in Scotch marine, steel firebox, water tube or cast iron boilers. Includes information and illustrations on installations. Iron Fireman Mfg. Co.

MECHANICAL POWER TRANSMISSION

129 Motorized Gear Drive — Bulletin 2350 describes Line-A-Spede motorized gear drives which are gear reducers powered by standard NEMA frame motors mounted on a shelf attached to the reducer. Illustrates construction features through cutaway view, and includes engineering specifications and dimensions. The Louis Allis Co.

130 Speed Reducers — Book 2618, 24 pp, describes a new line of shaft-mounted speed reducers. Contains engineering and selection information on: single reduction drives in six sizes, with nominal ratios of 5 to 1 and capacities to 50 hp; and double reduction drives in seven sizes, nominal ratios of 15 to 1, up to 40 hp. Includes dimensional data, and illustrates drive assembly arrangements, V-belt positions, tie rod and tie rod plate locations. Link-Belt Co.

131 V-Belt Drives — How to get longer life from V-belt drives is discussed in 12-pp illustrated Catalog IP-1577. Tells how to select and install V-belts, how to detect V-belt trouble, diagnose belt failures, correct drive troubles. Tips on V-belt maintenance are included. B. F. Goodrich Industrial Products Co.

132 For Power Transmission — Bulletin 3101, 8 pp, covers sheaves, variable-pitch sheaves, V-belts, flat-belt pulleys, pillow blocks, flange units, take-up bearings, couplings and timing-belt drives. Photos and dimensional diagrams are included, as well as selection tables. T. B. Wood's Sons Co.

133 Heavy Duty V-Belts — Design and selection of heavy duty V-belts is discussed in 16-pp Bulletin DH-301, a condensed catalog. Drive selection tables are provided, as well as installation suggestions. Construction features of company's V-belts covered. The Gates Rubber Co.

134 Spherical Roller Bearings — Design and application of spherical roller bearings is covered in 50-pp Catalog 258. Complete dimension tables, load ratings expressed as basic dynamic capacity, and line graphs showing modifying speed and life factors are included, as well as dimensional diagrams, engineering data, and information on typical applications. Book is available to qualified power engineers. The Torrington Co.

REFRACTORIES, INSULATION

135 Refractory Products — Three illustrated and descriptive bulletins on refractory products are offered by this manufacturer. Bulletin 3 features fire brick cement, Bulletin 17 covers plastic fire brick, and Bulletin 27 contains illustrated application pointers on castables. Botfield Refractories Co.

136 Insulating Material — This folder contains information on a foamed silica material for insulation and refractory applications. A list outlining physical characteristics of the material, along with recommendations for its possible uses, is contained in the folder, and sizes and shapes are illustrated. Pittsburgh Corning Corp.

CONSTRUCTION

137 For Drainage, Construction — Twelve-pp Catalog GEN-10658 features drainage and construction products for industrial uses. Included are data on corrugated metal pipe and pipe arch; paved-inert pipe and pipe-arch; Asbestos-bonded pipe and pipe-arch; multi-plate pipe, pipe-arch and arch; perforated pipe; water control gates; guardrail; liner plates; bin-type retaining walls; and steel sheeting. Armco Drainage & Metal Products, Inc.

138 Grout Cement — Bulletin 108A describes a colored acid-proof grout cement for brick, tile and glass block. Advantages and applications are described, method of grouting new and existing floors detailed, and physical properties of the cement listed. Nukem Products Corp.

ELECTRICAL

139 Breaker Selection Guide — Compact, pocket-size Bulletin 5004-1A presents construction and performance features, ratings and details on molded-case circuit breakers with ratings of 10 through 800 amp, and on enclosures for these breakers with NEMA 1 through 12 classifications. A master selection chart groups breakers by types and current ratings and lists under each the voltage and interrupting ratings for a-c and d-c units, descriptions of overcurrent devices and accessories and modifications. I-T-E Circuit Breaker Co.

140 Rectifier Transformers — Bulletin GEA-6845, 6 pp, provides information on construction features and function of mercury arc rectifier transformers used in electrochemical, transportation and industrial applications. It includes photos, circuit diagrams, rating tables and a listing of accessories. General Electric Co.

141 Rectifier Equipments — Bulletin GEA-6849, 12 pp, describes features and characteristics of self-contained, metal-enclosed power rectifier unit substations for industrial, transportation and electrochemical applications. Includes description of substation components, photos, line drawings, comparative power cost curves, a guide illustration for estimating savings in d-c power conversion costs, and a list of available publications on components. General Electric Co.

142 Trolley Busway — Bulletin 60 contains 40 pp of information on company's 60-amp steel-enclosed trolley busway electrification system, as well as a 20-amp trolley, an enlarged line of standardized curved track sections and other items. Illustrates and describes the track, trolleys and accessories used in electrification of light tonnage cranes and hoists, assembly and production lines, moving test lines, lighting, others. Feedrail Corp.

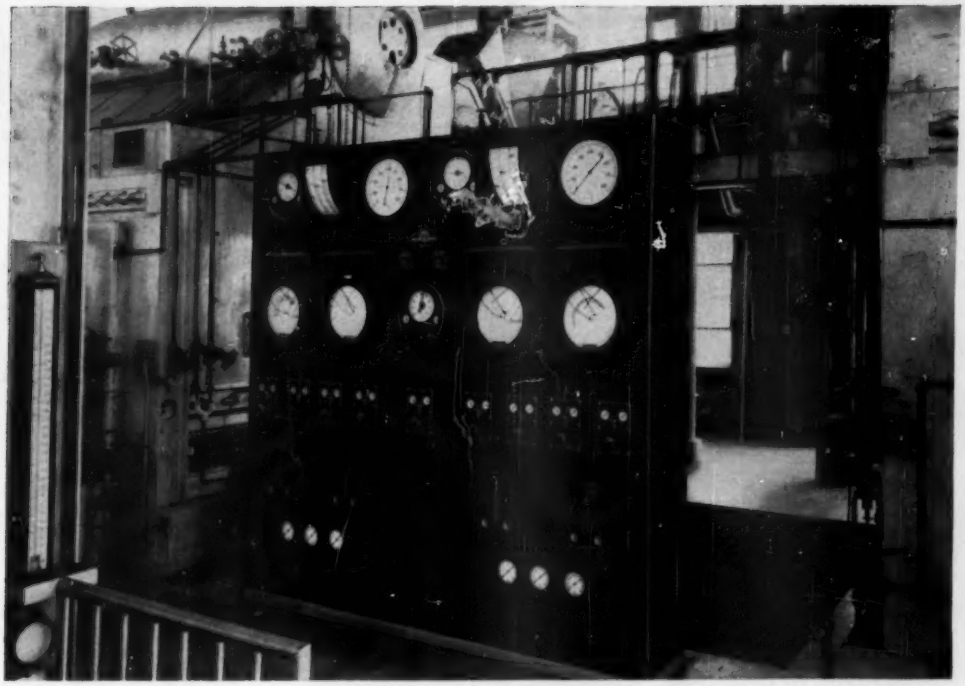
143 Portable Distribution System — Described in this 30-pp catalog is a portable distribution system for electric lighting and power, including such applications as portable lighting, heating and ventilating equipment, welding machines, power tools, and lighting transformers. System diagrams showing how each unit fits, and where it is located in the catalog are included. Whitney Blake Co.

144 Flexible Cords — Bulletin 1108, 64 pp, combines technical information and a catalog of flexible cords and portable cables. Dealing completely with company's mold-cured Okoprene sheathed cords and cables, the book's main divisions give dimensional data, engineering information, and splicing and terminating instructions. The Okonite Co.

145 Lightning Arrestors — Magnevalve station-class arrestors, 60 to 276 kv, are described in 12-pp illustrated Bulletin GEA-6794. Performance and application data, dimensions, and protective characteristics are tabulated; construction features, gap design, and anti-contamination features are described. General Electric Co.

146 Automatic Reclosers — Bulletin GEA-6671, 8 pp, describes the features and operation of company's automatic reclosers which provide economical overcurrent protection for suburban and rural distribution systems. It includes charts and rating tables. General Electric Co.

147 Reduced Voltage Starters — Design features of automatic reduced voltage starters are described in 12-pp Bulletin 14B8192. Includes motor control for centrifugal compressors, pumps, large conveyors, large fans, other applications. Lists advantages of autotransformer, closed



Bailey Meters and Controls for two boilers in a midwestern milling company.

How Bailey helps you get a new boiler off to a fast, safe start——

--The thrill of putting a new boiler "on-the-line" can be marred if you lack adequate metering and control equipment. You are a lot surer of a fast, safe start and dependable operation for a long time when you specify Bailey Meters and Controls. They are keys to peak efficiency and low operating costs.

Bailey is the choice of virtually all the most efficient plants on the Federal Power Commission's heat rate report. Here's why:

1. A Complete Line of Equipment

You can be sure a Bailey Engineer will offer the right combination of equipment to fit your needs. Bailey manufactures a complete line of standard, compatible pneumatic and electric metering and control equipment that has proved itself. Thousands of successful installations involving problems in measurement, combustion, and automatic control are your assurance of the best possible system.

2. Experience

Bailey Engineers have been making steam plants work more efficiently for more than forty years. Veteran engineer and young engineer alike, the men who represent Bailey, are storehouses of knowledge on measurement and control. They are up-to-the-minute on the latest developments that can be applied to your problem.

3. Sales and Service Convenient to You

There's a Bailey District Office or Resident Engineer close to you. Check your phone book for expert engineering counsel on your steam plant control problems.

A131-1

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Quiet, Efficient, Convenient

Ideal for Hospitals, Hotels, Apartments, and Industries where noise is objectionable.

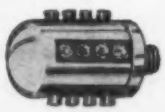
Rotojet Electric Tube Cleaner thoroughly cleans straight tubes from 25/32" to 4" I.D. in boilers, condensers, evaporators, and heat exchangers so quietly that it can be operated without disturbing anyone.

This self-contained unit comprises a powerful motor, rotatably mounted on a stand, a required length of heavy duty flexible shaft, a 20 ft. cable, and a selection of heads, brushes, drills, and scrapers to meet any cleaning need. The motor swivels and rotates so that tubes on top, bottom, and sides can be cleaned without moving the unit. A few of the many types of heads available are shown below.

Bulletin 107 gives full details of this quiet, efficient, convenient tube cleaner. Send for it now.

Rotojet Electric Tube Cleaner with swing-frame head.

4-way drill and universal coupling.



Expanding wire brush.

ELLIOTT COMPANY – ROTO PLANT
Tube Cleaner Specialists Since 1910
147 Sussex Avenue, Newark, N. J.

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transitions connection, primary resistor and reactor, part winding and star-delta starters. Covers theory and operation of low voltage starters. Also gives starting characteristic calculations, horsepower ratings. Allis-Chalmers Mfg. Co.

148 For Hazardous Locations — Six-pp Bulletin 2710 describes design and construction principles involved in manufacturing condulet electrical equipment for hazardous locations. Also emphasized is variety of explosion-proof equipment in everything from lighting to motor controls. Crouse-Hinds Co.

149 For Hospital Safety — Sealed safety switches, sealed safety receptacles, feed-in plugs, vented clock, pilot lights, switch Unilets, grounding Unilets, current taps and other equipment designed to protect against fire and explosion hazards in hospitals are described in this 12-pp bulletin. Illustrations and dimensional and rating data provided. Appleton Electric Co.

150 Tong Test Ammeter — This 8-pp bulletin pictorially illustrates eight types of instruments and gives detailed information on the selection, ordering and use of Tong Test ammeters for measuring both a-c and d-c. Includes typical scale ranges. Columbia Electric Mfg. Co.

ENGINES, TURBINES

152 Diesel Engines — Drilling engines, diesel-electric drilling rig power plants, and engine-generator sets made for oil field and other applications are covered in 20-pp Bulletin 106. Summarizes performance characteristics of 26 engine models, naturally aspirated or supercharged, and operating on natural gas, diesel, or dual-fuel. Specification tables and dimensional drawings are included. White Diesel Engine Div., The White Motor Co.

153 Gas Turbines — Salient design features of company's gas turbines, types of fuel (natural gas, distillate, crude oil) plus applications in oil fields and process industries are discussed in 14-pp Bulletin 167. Also included is an assessment of the integrated turbine-boiler package and likely future trends in turbine application. Clark Bros. Co.

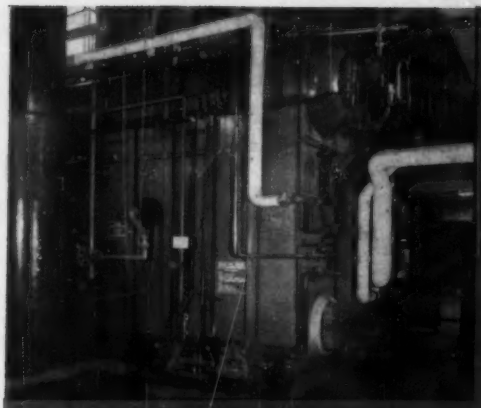
METALS

154 Steel and Aluminum Data — This new 156-pp edition of company's Data Book includes aluminum analyses, characteristics, mechanical properties and tolerances, in addition to information on steel such as machining and fabricating data, manufacturing practices and tolerances, weights, safe loads, ASTM standards, compositions and properties, and miscellaneous facts of practical value. Book is available to qualified power engineers. Please state your job title when requesting it. Joseph T. Ryerson & Son, Inc.

155 Steel and Alloy Plate — This 8-pp bulletin describes fabricating facilities for steel and alloy plate. Featured are pressure vessels, tanks, fractionating columns, large O.D. piping, field-erected breechings and stacks — shop fabricated, x-rayed, stress relieved and field erected. Missouri Boiler and Tank Co.

COAL HANDLING

156 Oscillating Conveyors — Book 2744, 24 pp, is devoted to company's Flexmount, Coilmount and Torqmount

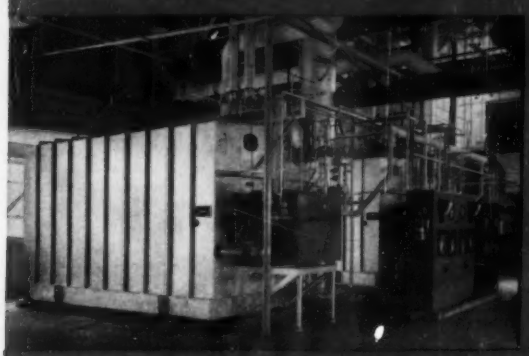


More Steam per dollar of investment with Vogt

PACKAGE WATER TUBE BOILERS

Completely shop fabricated, with burners, controls and accessories installed before shipment.

Placed on a suitable foundation, only fuel, water, breeching and steam connections need to be made to place unit in operation. Vogt Package boilers are available in oil and/or gas fired types in standard pressures of 175, 250 and 375 pounds per square inch gage.



Two 25,000 lbs/hr units installed in a manufacturing plant

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LOUISVILLE, KENTUCKY

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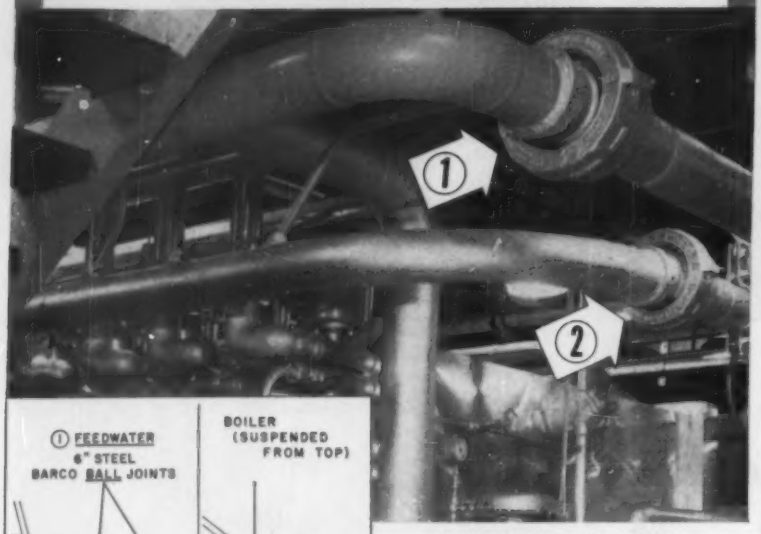
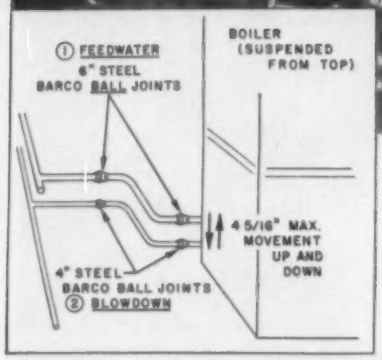
. . . where BOILERS move UP and DOWN





BARCO Ball Joints

The schematic diagram at left shows how Barco Flexible Ball Joints of steel construction are used in a new Florida utility plant—design pressure 600 psi, 500°F. The above photo shows a close-up view of two of the joints (see arrows). Two more matching joints, 4" and 6", are located out of the picture to the left. The 4" joints have metal gaskets. The same utility also uses 10" Barco joints on gas fuel lines. Other uses in power plants are for flexible connecting lines to oil burners, soot blowers, and other auxiliary equipment.

Flexible Pipe Connections!

The rapidly increasing use of Barco Flexible Ball Joints for solving piping problems in POWER PLANTS is significant for several key reasons:

1. Substantial *space saving* as compared to other methods in crowded piping areas.
2. Unlimited flexibility and movement. Utmost simplicity.
3. No heavy pipe anchoring required. No "end thrust" developed under pressure.
4. Ability to handle compound movement (where twisting is combined with thermal expansion and contraction).
5. Easy to engineer joints into piping to provide for any degree of flexibility, expansion, or movement required.
6. Maximum safety for high temperature applications. All-metal construction available. Special alloys can be specified.
7. Basic design is pressure sealing against leakage and self-adjusting for wear.
8. Virtually no deterioration. Able to stay in service for years without repairs or maintenance. No lubrication.

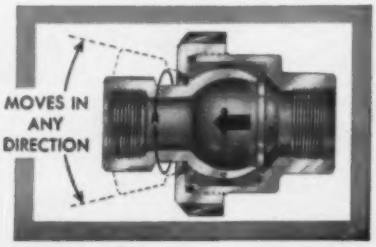
New Bulletin No. 31 contains interesting diagrams showing how to solve many common pipe expansion problems EASILY, ECONOMICALLY. *Ask for a copy;* see your nearest Barco representative or write:

BARCO ANNIVERSARY 50TH

BARCO MANUFACTURING CO.
5748 Hough Street, Barrington, Illinois

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Rotary Joints

In Canada: The Holden Co., Ltd., Montreal



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conveyors. These oscillating conveyors cover a material capacity range from 25 to 350 tons per hour. Product information provided includes trough widths, depths, section lengths, accessories, selection and application data. Also included is discussion of oscillation as a preferred method of conveying hard-to-handle materials. Link-Belt Co.

157 Coal Outflow Regulator — A device that regulates the outflow of coal and other bulk solds by gravity from bins and silos at speeds to 7000 lb a minute is described in Bulletin BD958. Illustrates various applications with conveyors and feeders. Fairmount Machinery Co.

158 Coal Handling — Sixteen-pp Bulletin A-2029 discusses increased importance of coal handling equipment in relation to over-all power plant design. Describes methods of handling coal at steam generating plants, including barge and railroad car unloading facilities, storage and reclaim, conveying and elevating, crushing, weighing, sampling, distribution to bunkers and dust control. Link-Belt Co.

OTHER EQUIPMENT

159 Shell, Tube Condensers — Form 8044, 16 pp, describes heavy duty, high capacity shell and tube condensers designed to simplify mechanical cleaning necessary in areas where poor water conditions exist. Dimensional data and diagrams are included, as well as selection data, heat of rejection curves. Hear-X, Inc.

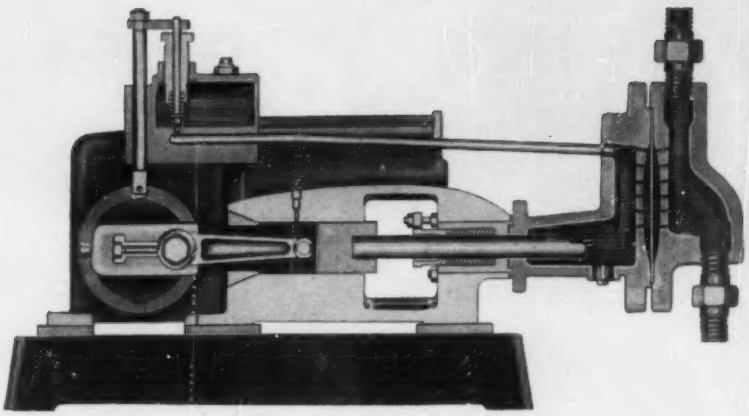
160 All About Slip-Sticks — This 24-pp booklet tells how to select a slide rule. Written and illustrated by Don Herrold, it describes slide rule scale designs and arrangements, materials used in slide-rule construction, and teaching aids and accessories for the slide rule. Also presents variety of company's slide rules including the Log Log Duplex Decitrig, the polyphase and Mannheim types, special purpose models. Keuffel & Esser Co.

161 Flexible Metal Connectors — Illustrated and described in 16-pp Catalog 658 is a wide selection of standard flexible metal hose connectors, as well as flexible nipples, pipe, pump connectors, vibration absorbers, Freon connectors, gas connectors, space heater connectors, dryer connectors, and water connectors. Specifications and installation information are included. Cobra Metal Hose.

162 Tube Expander Drives — Data on Torq-Air-Matic automatic tube expander drives, including heavy-duty models, is provided in illustrated 6-pp Bulletin 581. A selection chart lists three basic models, for condensers and evaporators, for heat exchangers and for boiler tubes, with information on different versions of each model, including torque, rpm, and tube size. Thomas C. Wilson, Inc.

164 Feedwater Treatment — Technical Bulletin 589 contains details on a hydrazine product for boiler feedwater treatment. Data is presented to show that the product reacts with oxygen without adding any dissolved solids to the boiler water. Betz Laboratories, Inc.

165 Industrial Dust Control — Advantages and features of company's flexible hose and duct for use in industrial dust control are detailed in Bulletin 82. Photographic case studies of typical applications are included, as well as selection, accessory information. The Flexaust Co.



This diaphragm pump can't air bind

. . . one of many reasons why you get reliability and accuracy with Milton Roy Controlled Volume Diaphragm Pumps

Take a good look at these outstanding features of the new Milton Roy Controlled Volume Diaphragm Pump:

- **no air pockets.**
- **positive mechanical valving bleeds air or vapor from hydraulic fluid automatically once each stroke.**
- **uniform pressure on both suction and discharge . . . diaphragms move without tendency to twist or bend.**
- **non-lubricating hydraulic system . . . fluid can be water, or other liquid.**
- **no moving parts to beat air into the hydraulic fluid.**
- **diaphragm liquid ends interchangeable in the field with Milton Roy packed plunger liquid ends.**
- **monel fillers . . . effectively seal and prevent cold flow of the plastic diaphragm.**

Standard liquid end designs are available for pressures to 1,000 psi and capacities from 1.1 to 138 gph . . . manual or automatic 0-100% capacity adjustment. Higher capacities available.

Take another look at the Milton Roy approach to your metering and pumping problems . . . write for detailed information to Milton Roy Company, 1300 East Mermaid Lane, Philadelphia 18, Pa.

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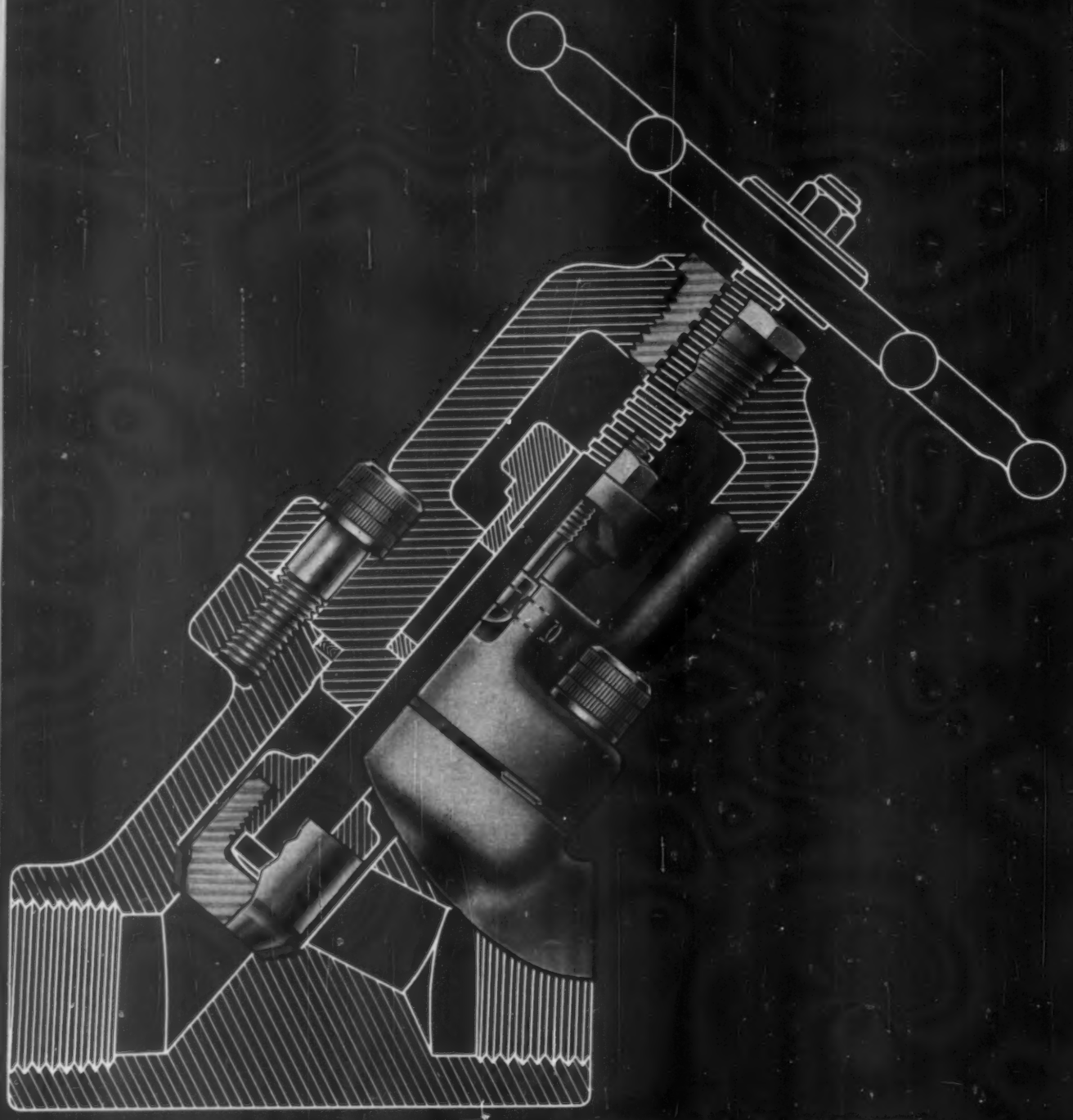

EDWARD "848" SERIES GLOBE VALVE
(ANGLE TYPE ALSO AVAILABLE)

What's New from Edward Valves

New Products . . . Problems and Solutions. . . Information on Steel Valves from Edward, Long-Time Leader in the Field!

Major Improvements at No Extra Cost Mark
New "848" Series Forged Steel Stop Valves

In an industry where any change in design is "news," Edward is proud to introduce a new line of 600-lb forged steel stop valves with so many major design improvements *at no increase in cost.* These Rockwell-built Edward valves are suitable for air, water, oil and other hydrocarbons, anhydrous ammonia and other gases, steam and other non-corrosive fluids.

NEW MATERIALS USED THROUGHOUT

Besides tough drop-forged steel, which is the basis of these valves, Edward introduces such innovations as stainless steel gland bolts, an aluminum-bronze yoke bushing, solid disk of chromium-cobalt-tungsten stainless steel, spiral wound gasket of stainless steel and asbestos, and special alloy cap screws linking body and bonnet.

NEW IMPROVED BODY-BONNET JOINT

Four molybdenum alloy cap screws secure bonnet to valve body. These compact, high-strength cap screws require less space than ordinary nuts and bolts, can be handled with one hand, and deliver maximum compressive force with minimum tightening torque. A new spiral wound gasket, consisting of some 20 turns of stainless steel and asbestos, provides controlled compression not possible with ordinary flat gaskets. Because this spiral wound gasket is free to expand and contract as needed, it "takes up the slack," maintains a leak-proof seal between body and bonnet.

NEW SOLID DISK OF SPECIAL ALLOY

Disk is made of chromium-cobalt-tungsten stainless steel. This new alloy has added resistance to erosion, holds its hardness better under high temperatures than other disk materials. Disk is lock-welded to disk-nut, eliminating wobble and chatter—especially important when valve is called upon for throttling duty.

INTEGRAL STELLITE SEAT FOR LONG LIFE

Valve seat is Stellite—a harder, longer-wearing material with excellent resistance to corrosion, erosion and temperature. Seat is integrally welded to body.

"848" SERIES ROCKWELL-BUILT EDWARD VALVES are available in ¼", ⅜", ½", ¾" and 1" sizes. They are rated at 600 psi—at 910F in carbon steel and at 1030F in chrome-molybdenum steel. Globe or angle types, with screwed or welding ends. Write for facts on performance . . . price . . . and delivery. Address *Edward Valves, Inc., 1202 West 145th Street, East Chicago, Indiana.* (Subsidiary of Rockwell Manufacturing Company.) Represented in Canada by Lytle Engineering Specialties, Ltd., 360 Notre Dame St. W., Montreal 1, Quebec.

EDWARD STEEL VALVES

another fine product by

ROCKWELL

Catalog 14 contains full data on the complete Edward line of forged and cast steel valves from ¼" to 18"; in globe and angle stop, gate, non-return, check, blow-off, stop-check, relief, hydraulic, instrument, gage and special designs; for pressure up to 10,000 lbs; with pressure-seal, bolted, union or welded bonnets, with screwed, welding or flanged ends.

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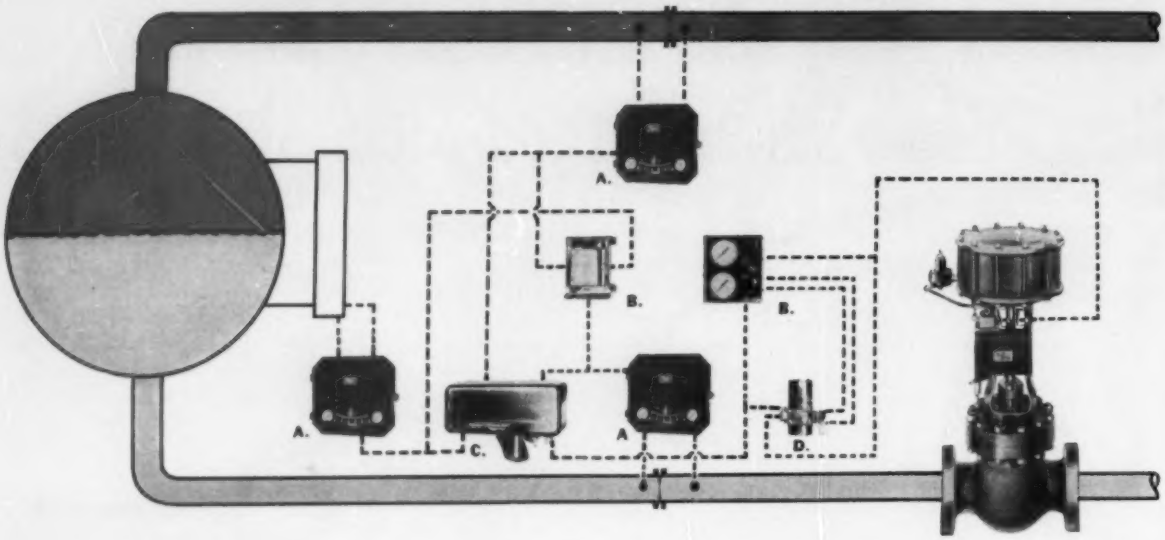
How Copes-Vulcan control systems boost power plant efficiency



Copes Feedwater Control brings stability to high-duty steam generators

To meet the higher ratings and fast load changes of today's boilers, Copes Type 3-L Feedwater Control combines the dynamic balance of custom-engineered control valves with precision-built instruments.

Feed to the boiler is modulated by steam flow, feedwater flow and drum water level. Feedwater input closely matches steam output on constant or varying loads. A stabilized water level is maintained regardless of changes in load or feed pressure, and while blowing down or blowing soot.

A complete line . . . a complete service

Over 50 years of design experience backs Copes-Vulcan's broad line of control systems for boiler cleaning, combustion, feedwater, pressure reducing and desuperheating operations.

For details, write for Bulletin 1013-D

A. Indicating transmitters send water level and flow influences to the computing relay where steam-flow and water-flow are accurately balanced.

B. Miniature recorders and transfer panel for console-type or graphic panels or for compact grouping on existing panels.

C. Compact beam-balanced type computing relay sends an air impulse to the controller and auto-manual transfer panel.

D. Transet controller provides two-knob tuning. Controller, transmitters and relays may be field mounted wherever most convenient.

E. Copes-Vulcan Type CV-P valve responds to minute changes in actuating impulse, delivers top power at the valve stem. For less demanding service Copes-Vulcan builds a diaphragm operated valve.

Copes-Vulcan Division

BLAW-KNOX COMPANY

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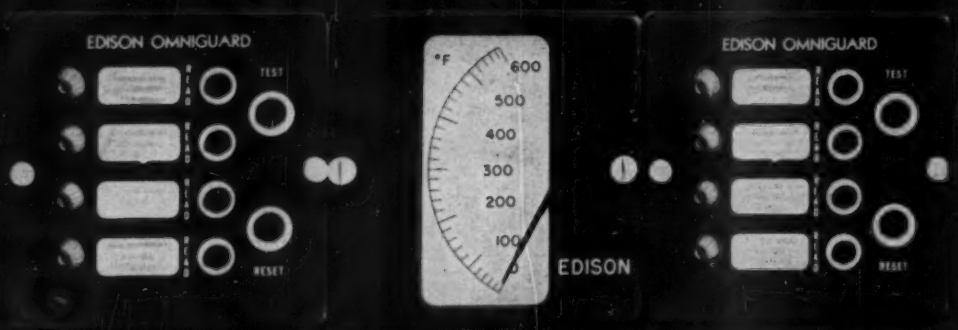
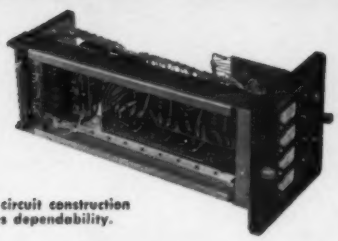
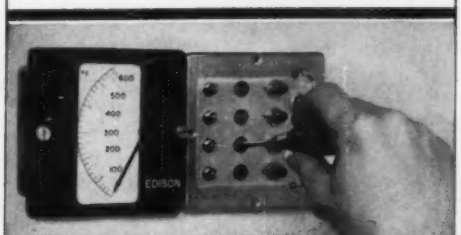




Printed circuit construction increases dependability.

Highest quality components, with no moving parts, assure maintenance- free operation.



Easy access to all components permits quick temperature settings and monitoring system changes – at any time.

Model 310 Edison Omniguard with Model 311 Indicator – a single indicator can read any number of temperature points.

THOMAS A.

EDISON

new model 310 omniguard temperature monitor... unmatched for versatility

The new Model 310 Edison Omniguard provides the simplest, most dependable temperature detection system yet devised... for both small and large installations.

The Omniguard system is reliable... flexible... economical. You order only the plug-in units needed, add new units as your monitoring needs expand.

Check these features of the new Edison Omniguard:

1. VERSATILE: One instrument can be used for both normally open and normally closed annunciator... for alarm or for shutdown of equipment.

2. FLEXIBLE: Quick, inexpensive system changes and additions . . . easy tie-in with any type annunciators or cut-off switches.

3. DEPENDABLE: Rugged design with highest quality components, no fragile moving parts.

4. SIMPLE: Single indicator reads any number of temperatures, needs no periodic adjustment. With a minute's briefing, *anyone* can operate the simple Omniguard monitoring system.

5. LOW COST: Plug-in units can be custom-tailored to your exact requirements . . . order additional units only when needed.

Thomas A. Edison Industries

INSTRUMENT DIVISION

37 LAKESIDE AVENUE, WEST ORANGE, N. J.

EDISON FACTORY OFFICES ARE LOCATED IN: EVANSTON, ILLINOIS; DALLAS, TEXAS; DAYTON, OHIO; SHERMAN OAKS, CALIFORNIA

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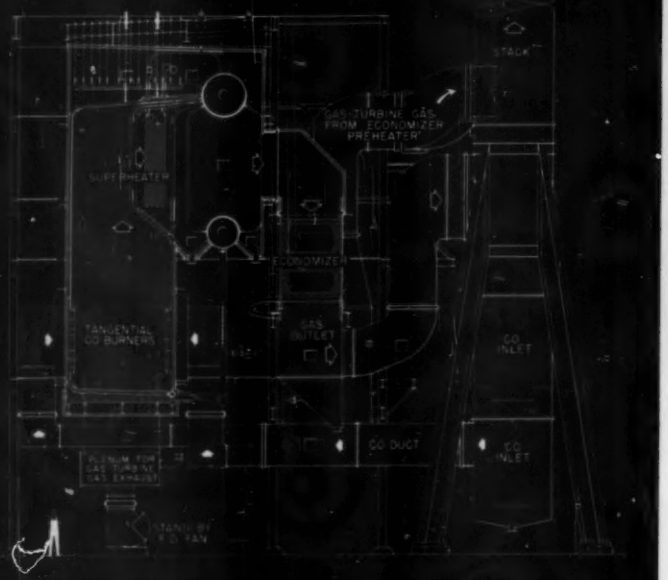
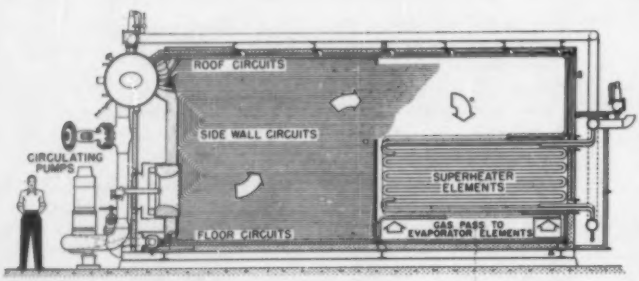
Special boilers for special



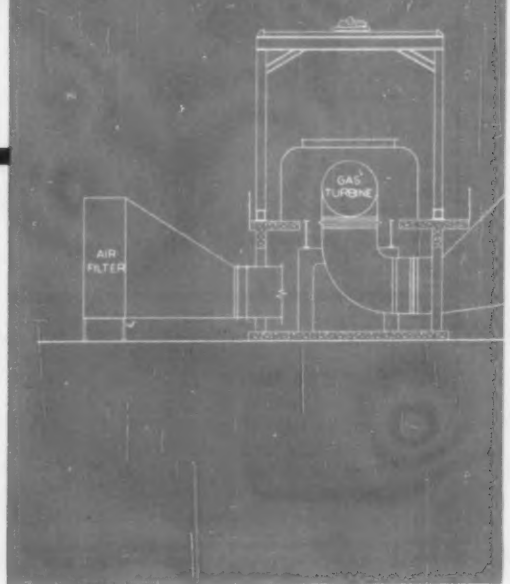
For refineries

C-E Vertical Unit Boiler, Type VU-40 CO — tangentially fired boilers to efficiently utilize energy potential in hard-to-burn waste catalyst regenerator gas. Illustrated is an installation at a Gulf Coast refinery. It combines a catalyst regenerator, two gas turbine-driven compressors, two CO boilers, and separate turbine-exhaust-gas feedwater heaters located between the boilers. Available in a wide range of sizes for any quantity of catalyst regenerator gas and for any steam capacity, CO Boilers by C-E have been in service more than three years.



For diverse industrials

C-E Package Boiler, Type PCC—new, completely shop-assembled, high performance, Controlled Circulation steam generator. Now in service with capacities to 120,000 lb/hr, it is available with temperatures to 900 F. and pressures to 1,000 psi (or higher if desired). This boiler is especially suitable where maximum capacity, temperature, and pressure are required, yet space is limited. Offers easy handling of rapid load swings and high quality steam production. PCC's in service include the world's highest capacity, highest pressure, and highest temperature package boilers.



C-E builds boilers of virtually all designs and types known in present practice . . . in capacities from less than 10,000 to 4,000,000 or more lb. of steam per hr. It is presently building units that will set new world records for capacity, pressure and temperature.

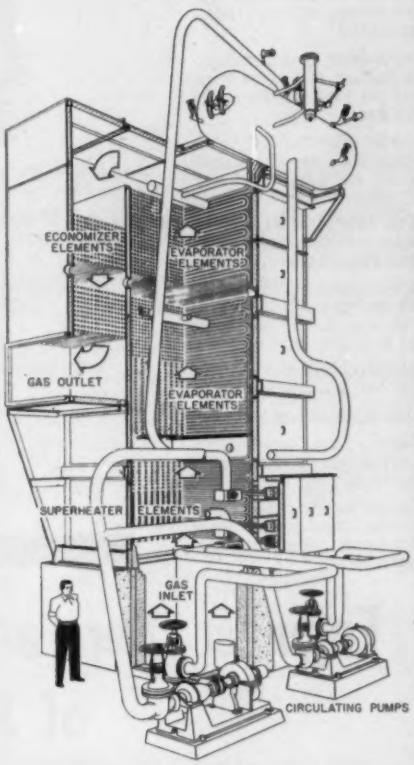
This vast experience has also been successfully applied to the development of many special designs to utilize waste fuels or to meet unusual steam requirements or space conditions.

A few recent examples of special C-E designs which have successfully met unusual problems are illustrated here. In several cases, this success may be attributed to the utilization of exclusive C-E developments such as controlled circulation or tangential firing.

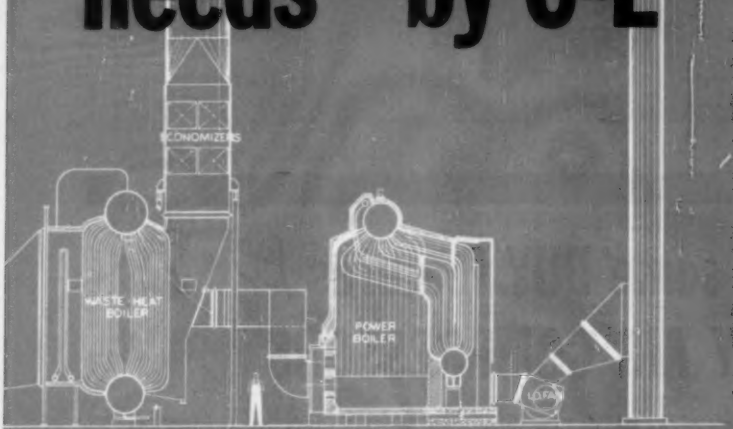
Whether your requirements call for boilers of unusual characteristics, such as those shown here, or for more conventional standard designs, come to C-E where you'll find the skill, experience, facilities—and desire—to meet your needs *exactly*.

For the steel and chemical industries

C-E Package Boiler, Type WCC—a Controlled Circulation design which utilizes waste heat from open hearths or chemical processes. The platen surfaces featured in the first pass permit passage of abrasive or "sticky" gas without erosion or bridging, prolonging boiler life and making the unit easier to clean. Controlled Circulation assures positive control of water to all circuits, permitting a smaller boiler with obvious space-saving advantages. Seven WCC's are now in service; eight others are being erected.



needs – by C-E



For gas turbine installations

C-E Gas Turbine Boiler—waste heat design for economical utilization of gas turbine exhaust sensible heat. Usable in a choice of cycles to obtain fired or unfired heat recovery and steam generation. Illustrated is a combined cycle, two of which are in service at a chemical plant. Here the turbine is followed by a waste heat boiler, multiple-purpose economizers (process and feedwater), and a conventional oil-fired steam generator which uses a portion of the high temperature exhaust gas for combustion air.

COMBUSTION ENGINEERING

Combustion Engineering Building, 200 Madison Avenue, New York 16, N. Y.

C-195

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

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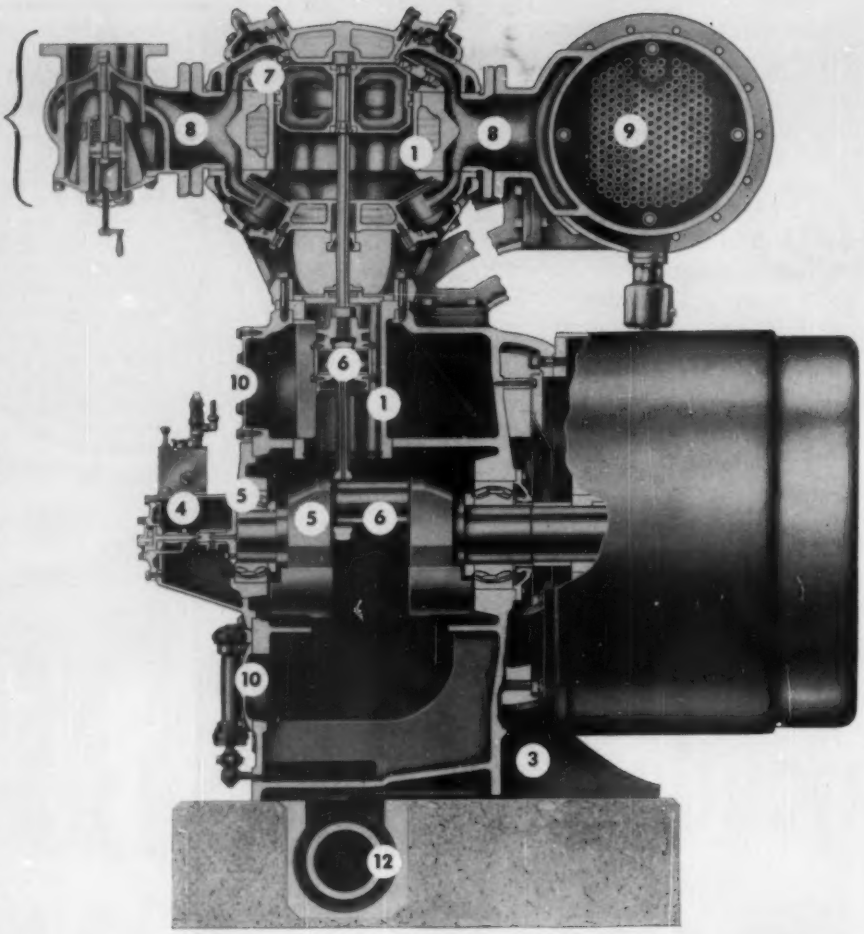

1. Honed, replaceable crosshead and cylinder liners of special alloy iron.
2. ✓ One-piece, box type tinned cross heads—NO ADJUSTMENT NECESSARY.
3. Scientifically ribbed, broad based main frame of semi-steel.
4. Integral force-feed running gear lubrication through rifle-drilled passages. Separate force-feed system for cylinders.
5. Heat-treated, drop-forged crankshaft and spherical-roller-type main bearings. NO ADJUSTMENT NECESSARY
6. Precision type, steel back crankpin bearings and bronze crosshead pin bearings, force-feed lubricated.
7. Patented "Dual-Cushion" Valves—large area, low lift, durable, efficient and quiet, set at most efficient angle in both heads.
8. Large, streamlined air passages minimize friction losses, reduce power consumption.
9. Dual copper tube intercoolers with cast iron shell for quiet operation, true counter flow design and built-in moisture separator
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12. Discharge piping furnished provides single outlet for easy installation.
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Mr. Engineer: Here are some BUY features of JOY AIR COMPRESSORS

There are three major by-products of the BUY features listed above; they are savings in *installation, maintenance* and *operation.*

INSTALLATION: Because of "Packaged" design, Joy Compressors are shipped ready to hook up and run. No assembly needed. And you save up to half the normal cost because Joy Compressors require less foundation.

MAINTENANCE: All wearing parts—valves, crosshead guides, cylinder liners, etc.,—are field replaceable. This is an exclusive Joy feature. No special tools or special maintenance crew training required.

OPERATION: Precise balance and control requires less horsepower than any other system, delivers greater economy on CFM and KWH per HP.

Joy Compressors range from 1.93 to 6048 CFM with wide choice of Prime movers and drives. Write ***Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.*** Canada: *Joy Manufacturing Company (Canada) Limited, Galt, Ontario.*

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Power Engineering

ATOMICS

308 EAST JAMES STREET
BARRINGTON, ILLINOIS

A POWER ENGINEERING FEATURE FOR UTILITY & MAJOR INDUSTRIAL EXECUTIVES

A. W. Kramer, Editor

A Periodic Report on Atomic Energy Development Throughout the World
Published by Technical Publishing Co.

January 1959

Operation Sunrise. As has been pointed out in these pages on several occasions, of all the nuclear power reactor concepts, the boiling water reactor is the simplest. It consists merely of an array of nuclear fuel elements immersed in a vessel of water. As the fuel elements heat up by virtue of nuclear fission, the water turns to steam, and this steam is delivered directly to a turbogenerator. Since the steam is generated at the pressure required for the turbine, the pressure vessel containing the fuel elements need be no heavier than that to contain the steam pressure needed for the turbine.

True, there are some drawbacks to this system but experience with boiling water reactors has indicated that these drawbacks are by no means as serious as at first supposed, indeed, because of the very favorable experience with EBWR, the Experimental Boiling Water Reactor at Argonne National Laboratory, and at its own Vallicetos plant, the General Electric Company has decided to go "all out" in the development of the Boiling Water Reactor, and have launched what they call "Operation Sunrise."

Operation Sunrise is a program for the development in depth of boiling water reactor systems to reach competitive nuclear power in seven years!

Specifically, the program includes:

1. A group of small and medium developmental nuclear power plants, to be in operation by 1962, which will provide technology leading to competitive nuclear power.

2. Evolutionary plants to be in operation by 1965, which will be competitive in their locations. These plants will produce power for under 8½ mills per kilowatthour.

3. Target plants to be in operation by 1970, which will be competitive with 25 per cent of the conventional plants then being installed in the United States. The larger plants will produce power for approximately 6½ mills per kilowatt hour.

4. Supporting research, development, and testing to make this possible.

This program is the result of a major effort by the General Electric Company to analyze the best course to competitive nuclear power plants in the United States. This effort has involved design studies covering promising reactor systems; analysis of the results of reactor programs to date; analysis of the development still required to support advanced designs; and the evaluation of the performance and economics of each system.

From these studies General Electric has concluded that current technology is now ready to support an intensive development program. Such an intensive development program can be proposed for any single reactor type at this time only if

the reactor is technically on solid ground now, if it promises clearly that further exploration is worthwhile, and if it affords a clear course of action towards the realization of that promise.

Boiling Water Reactor Ready for Intensive Development. General Electric is convinced that the boiling water reactor meets these conditions better than any other type, and for these reasons:

The technological foundation is established. Experimental data is at hand on the design, construction, and operation of five first generation boiling water reactors. Boiling water reactors at Vallecitos and Argonne are operating successfully, producing more power than expected. In addition, the large-scale Dresden of the Commonwealth Edison Co will be completed in 1960.

The safety characteristics of the boiling water reactor have been proved in the AEC's BORAX and SPERT experiments, the only comprehensive safety experiments that have been performed for any type of reactor to date.

The low-enrichment uranium-oxide fuels have demonstrated their feasibility for commercial service. Feasible manufacturing processes are developed; oxide fuel is corrosion resistant and stable under irradiation; and many opportunities exist for further cost reductions.

The lowest capital costs of all proven reactors are those of boiling water reactors. G-E claims that it has been able to predict construction costs accurately. Dresden is proceeding within the original budget; the Vallecitos plant was completed under the budget.

The boiling water reactor according to G-E is the leading contender for competitive nuclear power today, and it is sufficiently adaptable to remain so into the foreseeable future. Its cost advantage, vast background of technology, momentum of current development programs, and potential for improvement, assure the boiling water reactor of attaining competitive nuclear power considerably ahead of any other type.

Operation Sunrise, therefore, is a program for the concentrated development of boiling water reactor systems to reach competitive nuclear power. It is based on the concept of development in depth of a single reactor type rather than development in multiple of many different reactor types.

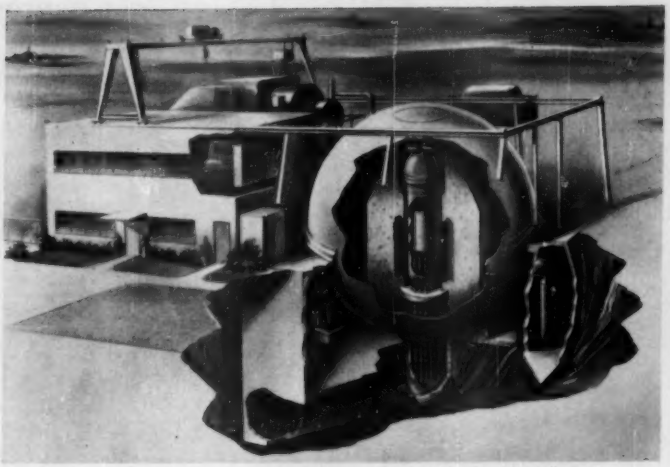
Operations Know-How, Sunrise. Actually, the General Electric plan comprises two nuclear development programs. First is Operation Know-How, a plan to educate Electric Utility company personnel and the public through the operation and display of small reactors all over the country. Under this part of the program, G-E can build and deliver 25 small, identical, reactor plants within three years. Based on the sale of these reactors, the estimated cost per completed plant would be approximately $4 million. This cost includes reactor, turbine-generator, auxiliary equipment and service buildings -- all installed -- as well as the first core fuel load and allowance for the cost of land and the cost of interest during construction.

While G-E is prepared to build 25 such small plants, it is expected that other manufacturers would be able to build at least an equal number. Each plant, powered by a boiling water reactor, would produce 5000 kw of electric power. To provide its rated output, the reactor will operate at a thermal power of about 22,000 kw and will produce some 66,000 lb of 650 psi saturated steam per hour. The nuclear plant, shown on the opposite page, can be furnished as a complete package, erected on the utility site, ready to operate.

Developmental Plants. There are seven possible developmental plants, each intended to improve and test a specific combination of phases of boiling water technology. It is estimated, however, that only five of these plants need be built. A typical combination of developmental plants is as follows:

1. A 50 Mw (e) natural circulation plant. This plant will provide the basis for developing a reactor line of extreme simplicity and low cost that will serve a market in the range of 10 to 150 Mw. It will exploit the simplicity of the "pot-pipe-turbine" concept of reactor design. This is the Humboldt Bay reactor to be

operated by the Pacific Gas & Electric Co. Since this plant is already committed, only four developmental plants remain.



2. A 25 Mw (e) compact plant. This will be a pilot plant directed toward attaining the ultimate in design and construction simplicity for forced circulation plants in the range of 75 to 300 Mw (e). This plant will be physically compact through the employment of an internal pump and recirculating loop, internal steam separation, and a novel control system. One version of this plant has been designed to utilize the hook-on principle and thus make use of a substantial portion of conventional equipment in an existing fossil fuel plant.

3. A 25 Mw (e) high power density plant. This plant will test the technical objective of at least doubling the steam output from a given reactor core, thus reducing the unit capital costs for large forced circulation reactors.

4. A 100 Mw (e) high power density plant. Extending the results of the preceding plant in the series, this plant will test the limits of power density that can be obtained in a medium-sized reactor; it will also provide a full-scale proving-out and improvement program on high power density fuel. This plant could be rated as high as 250 Mw (e).

5. A 50 Mw (e) separate nuclear superheater. This could most advantageously be hooked on to an experimental boiling water plant. This installation will test and demonstrate the possibility of improving thermal efficiency through the technique of nuclear superheat and thus reach a further technical objective.

Evolutionary Plants. The experience gained with the developmental plants will make it possible to proceed directly to the next major step in "Operation Sunrise" -- medium and large scale evolutionary plants. The purpose of these plants is to act as a bridge between the developmental plants and the much larger and more sophisticated plants to follow. They are necessary as an intermediate and risk-reducing step. This step would involve the construction of three possible lines of plants, a 100 Mw (e) natural circulation boiler with internal circulation and internal steam separation; a 200 Mw (e) forced circulation boiler, single cycle with close-coupled recirculation loops, high power density in a large core, and high pressure saturated steam; and, a 325 Mw (e) boiler-superheater combination. This plant will furnish design, construction, and operating experience with the first nuclear superheating reactor of economic size. This type of plant would have a heat rate of 9500 Btu per kwh, with steam at 900 F and 915 psi.

These three evolutionary plants will not be the maximum practical size, and thus will not have the lowest unit capital cost, but they will be large enough to demonstrate fuel costs in the range of 2 to 2½ mills per kwh. Their total power cost will be under 8½ mills per kwh, making them economically competitive in selected locations with fossil fuel plants going into service during the 1960's.

Target Plants. Following the evolutionary plants will come the target plants which will show better costs because of their increase in unit rating, increase in scale of manufacturing and construction operations, and simplification in design, manufacturing, and operating experience. Here, G-E sees three lines of plants corresponding to the three evolutionary plant lines. For example, one possible target

plant is a 450 Mw (e) high power density plant with a separate superheater and the whole system housed in a low-pressure containment structure.

The target plants will have capital costs in the range of $175 to $225 per kilowatt (at today's dollar values) and fuel costs in the range of 1.7 to 2.2 mills per kwh. This leads to total power costs as low as 6½ mills per kwh for the largest units. This figure is based on 0.70 per cent load factor and 14 per cent capital charges.

REPRINTS OF ATOMICS

Reprints of the ATOMICS sections from POWER ENGINEERING for the six months from July to December 1958 will be available about the middle of January, 1959. We will print only enough of these, however, to take care of advance orders. They will be available at $1.00 per copy. If you want one of these reprints, please enclose $1.00 in an envelope, and send it to:

ATOMICS Reprint
c/o POWER ENGINEERING
308 E. James Street, Barrington, Illinois

Total Cost. General Electric estimates that this program which would place competitive nuclear power in the industry in the next seven years, will have a total gross cost of $128 million. This includes about $90 million for construction of the four new developmental plants and $38 million for research and development. The figure does not include the cost of the evolutionary or target plants because these plants, wherever they are built, will be economically justified as a conventional plant would be.

Significance of the Plan. The General Electric proposal which was made at a conference of electric utility executives at Woodside, California last September, carries with it a warning, that unless the electric utilities develop a nuclear power development of their own, they will pave the way for a large-scale program by the federal government for the construction of nuclear power plants. As pointed out by Francis K. McCune, General Electric's vice president for atomic energy, at this meeting, the Congress has already restored the first-year construction funds for this country's first commercial gas-cooled reactor, and the AEC was free to go ahead on its own in the construction of such a plant if no industrial proposal was made. (Note: On November 24th the AEC received a proposal to build such a gas-cooled, graphite-moderated reactor from the Philadelphia Electric Co and High Temperature Development Associates, Inc.)

Mr. McCune, in making the G-E proposal had two arguments for increased activity in nuclear development by private utilities: First, reactor development acceleration is now public policy in the United States, largely for the maintenance of international prestige. Second, unless private industry develops a nuclear program of its own, the government will lay out an accelerated program for the construction of government owned plants during the next year. Left to its own devices, Mr. McCune said that U. S. industry would attain economic power "on a time scale commensurate with the demands of our domestic economy." But, because acceleration "is here and it is irrevocable" the only remaining question is: "How should the program be implemented?"

Each step of a government program, Mr. McCune warned, would be planned and controlled by specific determination of the government while, under the G-E plan the utilities would have the opportunity to prove through positive action that competitive power from the atom can best be accomplished through the free enterprise system.

SENN. In view of General Electric's faith in the advantages of the boiling water reactor it is of great significance to learn that the Societa Elettronucleare Nazionale (SENN) of Italy, selected the boiling water reactor for the 150 Mw nuclear plant to be built near Naples. The G-E boiling water plant was selected by SENN after a seven-man team of international nuclear experts on behalf of the World Bank and the Italian government had evaluated nine power station proposals by four countries.

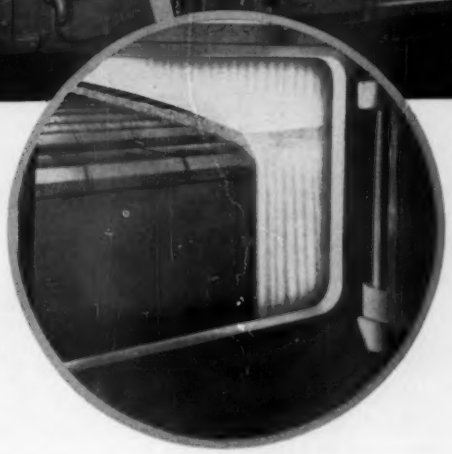
Andrew W. Kramer

A STANDOUT UNDER ANY TEST

DETROIT ROTOSTOKER C-C (Continuous Cleaning)

In any test you want to apply DETROIT ROTOSTOKER C-C *(Continuous Cleaning)* will stand out

Detroit RotoStoker C-C (Continuous Cleaning) with reciprocating grates that continuously clean the fire and discharge ash at the front, where it may be taken from the ash pit at floor level if desired, avoiding need for a basement ash bunker. High sustained efficiency, high availability low power for operation — For boiler capacities from 5,000 to 75,000 pounds steam per hour.



Efficiency, availability, flexibility under fluctuating load, ability to burn good or low grade coals or waste materials, durability, low parasite power consumption and low maintenance. RotoStoker C-C scores high on all points.

Among those who have tested the RotoStoker C-C — found it a winner — are such well known names as:

Allied Chemical & Dye Corporation
Alpena Power Company
American Cyanamid Company
American Radiator and Standard Sanitary Corp.
The Electric Auto-Lite Company
Automatic Electric Company
Carlisle Tire & Rubber Company
Columbian Carbon Company
Darling and Company
E. I. du Pont de Nemours and Company
General Motors Corporation
General Tire & Rubber Company
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National Gypsum Company
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U. S. Dept. of Defense
Wake Forest College

RotoStoker C-C is typical of the Dependable Detroit Line which includes stokers for efficient firing of boilers from 3,000 to 400,000 pounds per hour steam capacity.

DETROIT STOKERS COST LESS: COST EQUALS INITIAL INVESTMENT PLUS UPKEEP PLUS PRODUCTION LOSSES DUE TO EQUIPMENT OUTAGE. THE TOTAL IS LESS WITH DETROIT.

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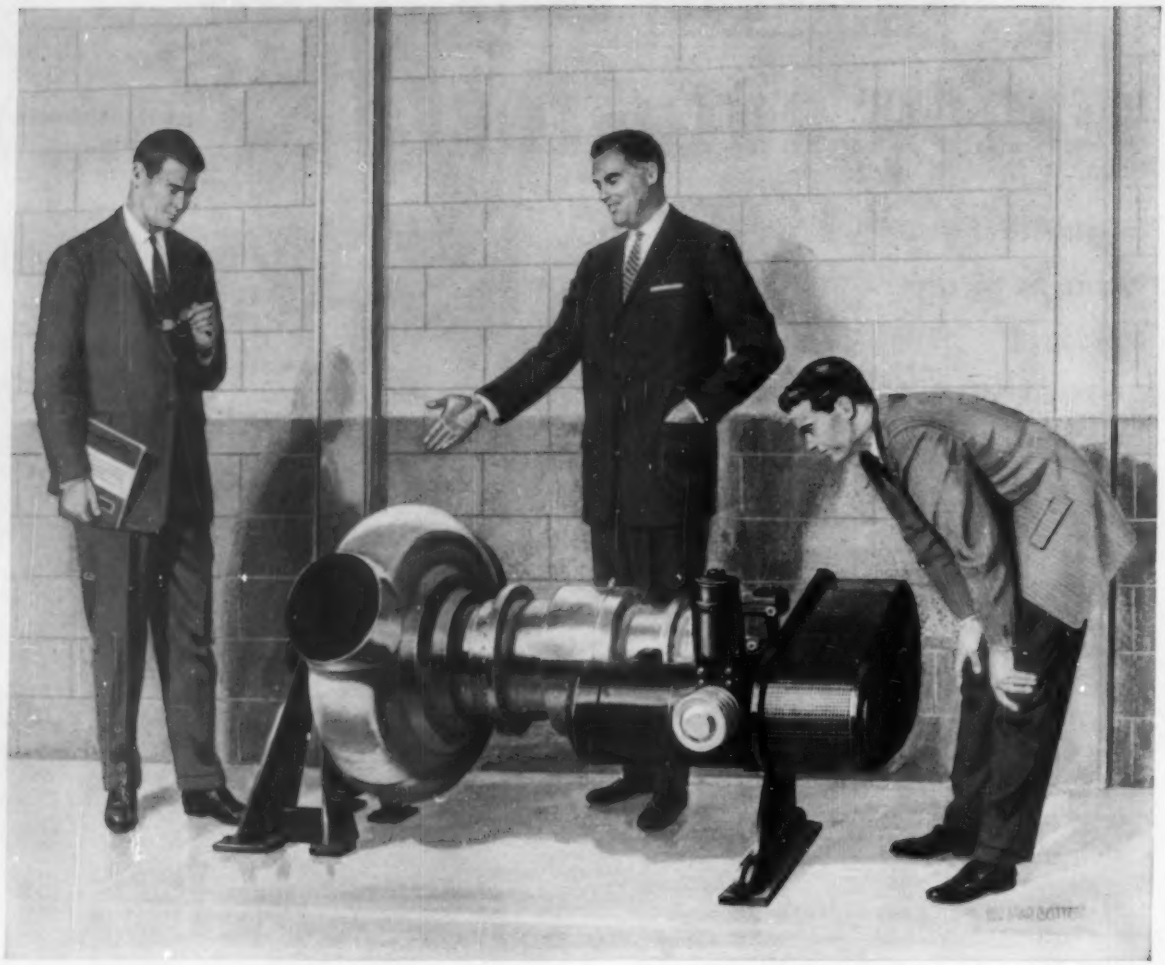

New 1100 hp Solar gas turbine offers small size, light weight, greater fuel efficiency

SOLAR'S NEW 1100 HP SATURN engine represents an important forward step in gas turbines. Advantages of the new power plant include these: it is extremely lightweight, averaging less than 1/10 the weight of conventional engines; it occupies only about 51 cubic feet; it starts instantly and takes full load without laboring in temperatures from −65F to 130F—even after long periods of standby service. In addition, the new Saturn engine offers an unequaled advance in gas turbine fuel efficiency, and it will operate on a great variety of fuels.

Today, proven-in-service Solar gas turbines—ranging from 50 to 500 hp—are creating new standards of performance and reliability. As propulsion units for speedy boats, as a power source for electric generators, as ground support units for advanced jet aircraft, as high-efficiency pumps and in other applications... Solar gas turbines are saving time and money for hundreds of satisfied users. Why not investigate the Solar family of gas turbines for *your* power needs? Write today to Dept. F-116, Solar Aircraft Company, San Diego 12, California.

CHARACTERISTICS OF THE SATURN GAS TURBINE

RATING	1100 hp (80F sea level)
WEIGHT	950 lb
OUTLINE DIMENSIONS (MAXIMUM)	
Length	69 in.
Width	45 in.
Height	44 in.

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LOW first cost
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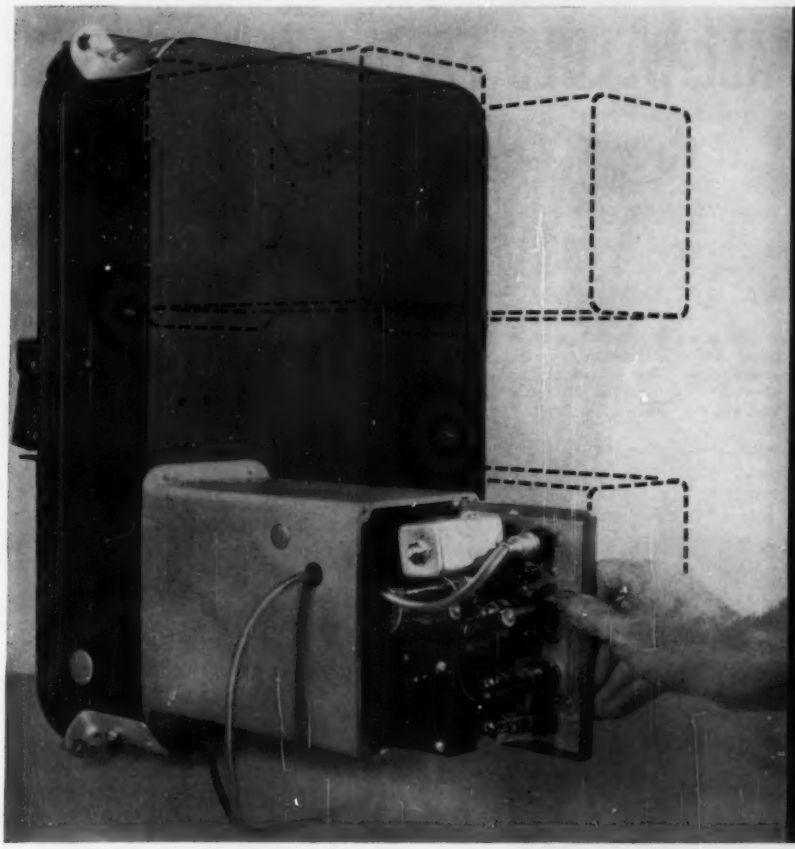

UNIQUE CONSTRUCTION—same amplifier used for all temperature applications by simply changing plug-in input box.

UP TO FOUR different variables may be recorded on the same chart.

ACCURATE—PowrLog's resolution is 0.1% of full scale, overall instrument accuracy—0.5%.

FAST—with pen driveshaft torque of 45 in./lb., PowrLog achieves full scale pen deflection in 2 seconds.

STABILITY ASSURED—simple adjustment balances gain to resolution, no hunting or dead band problems.

The Hagan model TC (thermocouple) PowrLog receiver provides low cost remote measurement and/or control of temperatures with a high degree of accuracy. The system consists of an amplifier, drive motor and gear train as the basic unit. Associated with this basic unit are a series of plug-in input boxes, one for each type of measurement. Every component part has been selected for reliability, accuracy and long wear characteristics. The net result is the reduction of maintenance costs and problems to a new low.

Since the same high-gain AC amplifier is used in all applications, parts stocking problems are eliminated, with consequent savings in inventory costs.

Write for descriptive bulletin, or ask a Hagan engineer to explain the many specific advantages of the new PowrLog for temperature measurement and other applications.

HAGAN CHEMICALS & CONTROLS, INC.

DIVISIONS: CALGON COMPANY, HALL LABORATORIES

HAGAN BUILDING, PITTSBURGH 30, PA.

In Canada: Hagan Corporation (Canada) Limited, Toronto
European Division: Via Fiumendosa No. 13, Milano, Italy

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HEADING FOR 5000 PSI

YUBA ALL-WELDED FEEDWATER HEATERS

Tubes are welded into tube sheets and then extensively tested against specimens of rolled joints. At elevated pressures, rolled joints leaked and blew out of the test bombs, but at 9600 psi the welded tubes held firm.

Twenty-five years ago it was an accomplishment to put 1000 psi into a feedwater heater. Ten years ago, 2500. Today Yuba feedwater heaters are at 4000 psi. Next step — 5000.

A chief reason for the present high pressures and the promise of even higher is Yuba's all-welded Multilok Closure design: tubes welded, not rolled, into tube sheets; shells welded to heads and channels. No flanges or bolting required. In the Multilok Closure, a split key ring in shear absorbs the force resulting from the internal pressure on the cover, and the steel torus ring welded to the channel and to the cover provides the hydraulic seal. Destructive tests on Yuba's well-known Multilok Closure proved the strength of the design of the split key ring construction and the soundness of the torus ring design.

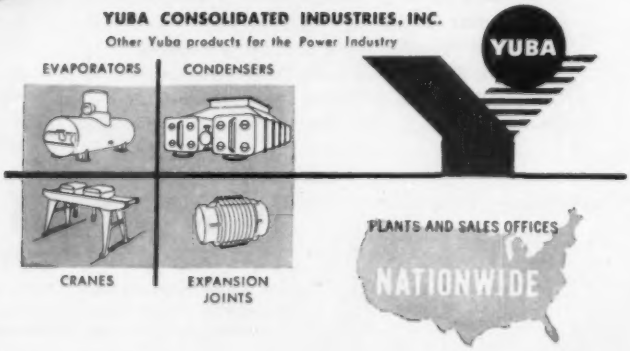
The all-weld design already has set an industry standard and its proved performance has brought orders from the major power companies here and abroad.

Your inquiry is cordially invited.

Power equipment engineered and manufactured by
YUBA HEAT TRANSFER DIVISION
Honesdale, Pa.

Production facilities in the west
YUBA MANUFACTURING DIVISION
Benicia, Calif.

YUBA CONSOLIDATED INDUSTRIES, INC.
Other Yuba products for the Power Industry



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HAGAN NEWSLETTER
Behind the Panel

HOW AUTOMATIC ARE AUTOMATIC CONTROLS?

The answer depends a lot on the reliability factor in the system, and on how well the various control elements are integrated. A great many control systems are designed to operate on full automatic only when the process is within normal operating range. In applications where the process can vary widely, or where operators must be relieved of control supervision during abnormal conditions, true automatic control is desirable. Hagan systems are designed to accomplish this; for example:

OUTDOOR BOILER CONTROL SYSTEM STAYS ON AUTOMATIC DURING GENERATOR TRIP-OUT: a new outdoor utility station in the Southwest experienced a generator trip-out, and in the excitement, the 3-element feed-water control system was left on automatic. Inspection of charts after the difficulty was overcome showed that the feedwater system had maintained proper drum level throughout the two hour shut-down, even though the system went through the complete shut-down, start-up cycle.

SOAKING PITS NEVER OPERATED ON MANUAL CONTROL: on a new installation of two batteries of 3 pits, the heaters are instructed never to operate on manual control. In case of control malfunction, the pits are shut down until the system is repaired. In a year of operation, this policy has resulted in the loss of only four pit hours production time. Pit bottoms have not built up excessively, indicating close control of combustion and absence of ingot washing. (Item A-1)

FIRST SOLID STATE ELECTRONIC BOILER CONTROL SYSTEM

Operational magnetic amplifiers, used as basic control elements in the combustion, feedwater, pump recirculation and steam temperature control systems, will be installed on a new 1,260,000 lb/hr boiler at a Southern utility. The Hagan proposal--for the first solid state electronic boiler control--was selected by the utility in competition with two other electronic systems that did not achieve the reliability inherent in a solid state system. (Item A-2)

ELECTRONIC TEMPERATURE CONTROLLER SENSES 0.000001 VOLT CHANGE

Ultrasensitive, the Hagan PowrAmp Temperature Controller is responsive to thermocouple output fluctuations of one-millionth of a volt. Designed for precise temperature control in situations where either the heater or the product temperature can change rapidly, the Controller provides adjustments for proportional band, reset, and rate action. While this is a new instrument, it has already been proven in action. It was selected for the critical job of controlling glass fiber drawing dies operating at 1600F and it is limiting die temperature fluctuation to less than 0.25F. The Controller provides stepless regulation and will handle up to 330 kva through saturable reactors. (Item A-3)

NEW POWRLOG OFFERS LOW-COST TEMPERATURE MEASUREMENT OR CONTROL

Our systems engineers wanted a rugged, low-cost remote recorder for process measurement in industrial applications. Once we decided that the right way to minimize maintenance was to make use of unitized construction, the acorn we had been asked for rapidly became a full fledged oak. We ended up with an instrument that will measure any function that can be converted into an error voltage, either AC or DC, and then convert these voltages into mechanical movement that may be used for driving a recorder, indicator, integrator, pneumatic transmitter or a controller.

Utilizing a unique amplifier that is adaptable to a wide variety of applications by means of plug-in input boxes, the new HAGAN PowrLog is particularly well suited for the remote measurement and/or control of temperature with either thermocouples or resistance bulb thermometers. The components of this versatile instrument have been selected for accuracy and high reliability--result--maintenance has been reduced to a new low. (Item A-4)

HAGAN CHEMICALS & CONTROLS, INC.
Hagan Building, Pittsburgh 30, Pa.

If you would like more information on any of the above items, check the appropriate box below.

☐ Item A-1 ☐ Item A-2 ☐ Item A-3 ☐ Item A-4

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Efficiently planned integration of all producing, processing and shipping operations at Peabody's multiple mines, assures users maximum value in the quality and performance of their coal.

The PLUS values in

PEABODY'S All-Inclusive COAL SERVICE

Every barge and carload of Peabody Coal is the reliable product of far-sighted planning and carefully integrated producing operations—

● ***large volume production from multiple mines; precision preparation; accurate application; on-schedule barge and rail transportation.***

But Peabody gives you more than these basic essentials. It is long range security—the security assured by expanding resources, extensive reserves, and the conscientious service of a responsible organization devoted exclusively to producing coal in economical abundance for Mid-America's increasing fuel needs. Your inquiries are invited.

PEABODY COAL COMPANY

PEABODY PLAZA—301 OLIVE STREET—ST. LOUIS 2, MISSOURI

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Less than ¼ turn opens or closes

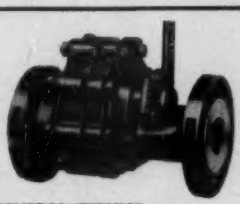
When you need...

- Quick action
- Leak-Proof Seal
- Minimum Pressure Drop
- Straight-through full flow
- Valves that cannot wedge or jam
- Self-grinding rotating disc

Specify Everlasting Valves

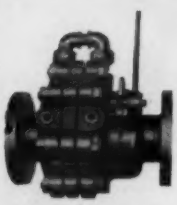
For more information WRITE for these bulletins.

BOILER BLOW-OFF
Quick acting, also handwheel operated "Y" and angle types. For pressures up to 600 psi.

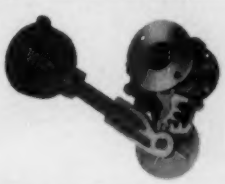


GENERAL SERVICE
Where drop-tight seal and full flow is essential.

CYLINDER OPERATED
Can be remotely controlled, electrically or manually.



STEAM JACKETED
Assures free flow of viscous materials.



WEIGHT-OPERATED
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Everlasting VALVES

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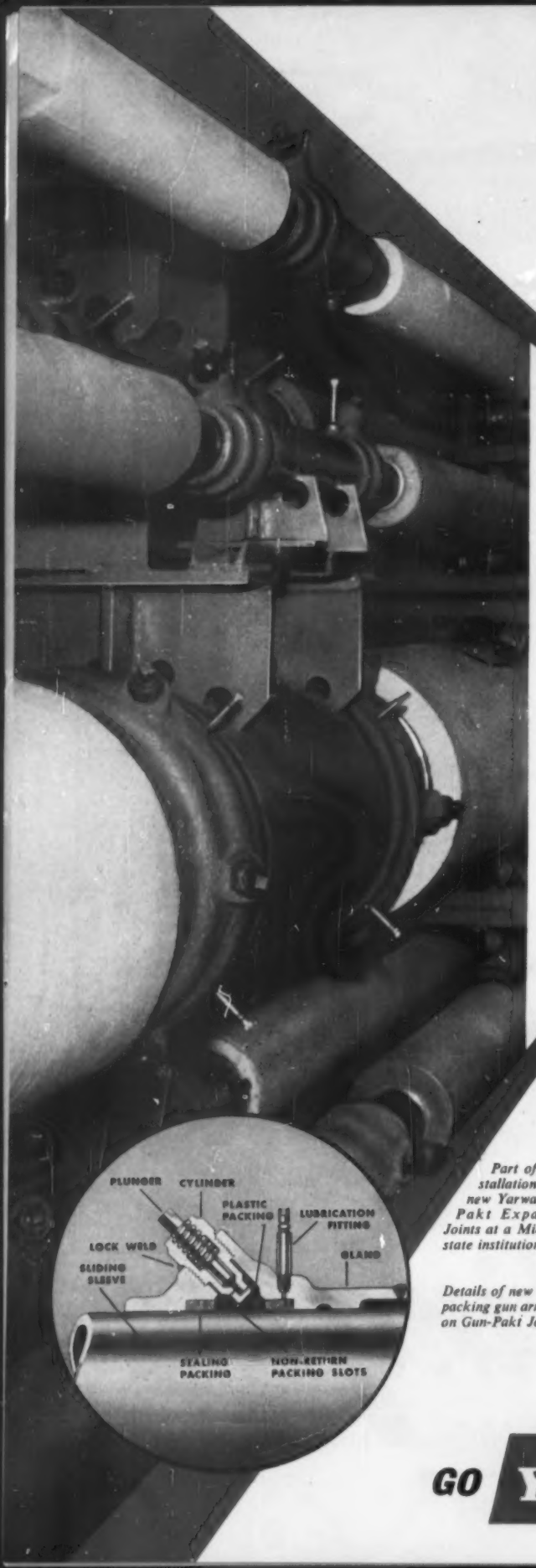

something great

has happened to steam lines..

..the improved

GUN-PAKT EXPANSION JOINT

Part of an installation of 37 new Yarway Gun-Pakt Expansion Joints at a Mid-West state institution

Details of new packing gun arrangement on Gun-Pakt Joints

With the many types of expansion joints available today for steam lines, it's important for engineers to "know their joints" when making a choice. Engineers know that Gun-Pakt maintenance costs have *always* been exceptionally low.

NOW . . . with the new Yarway Type W Gun-Pakt expansion joint you have these important *added* advantages—

CONVENIENCE—improved angle of packing guns makes them more accessible, thus reducing maintenance costs.

INCREASED STRENGTH—thanks to new one-piece integral body and gland.

LOWER MAINTENANCE—new packing gun design permits injection of special plastic packing *directly into packing space under full steam pressure. No need for costly shut-downs for repacking.*

Now is the time to find out more about Gun-Pakt joints. Write for Yarway Bulletin EJ-1916.

YARNALL-WARING COMPANY
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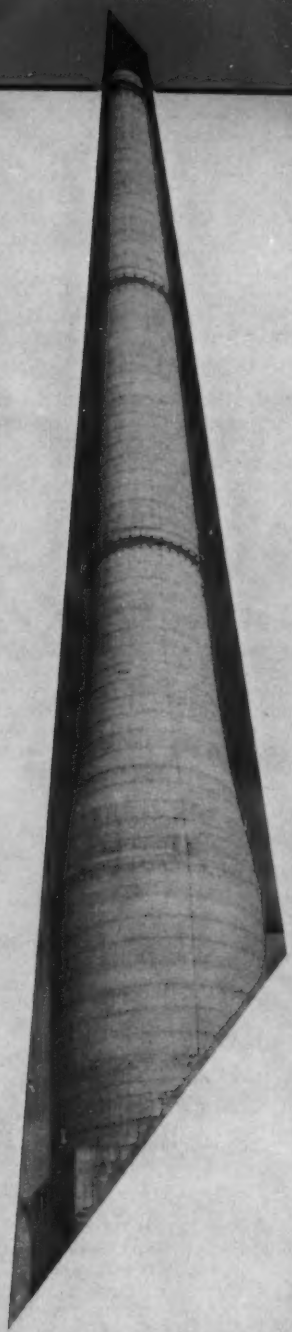
GO YARWAY WITH CONFIDENCE

What's Ahead

IN POWER ENGINEERING



YOUNG ENGINEERS face one of the most dynamic challenges of the century in the field of power engineering today. The challenge is detailed in the articles on the following 20 pages. More young men are vitally needed to meet this challenge. Deans of engineering colleges, and many practicing engineers, tell us that not enough of these young men are entering power engineering.

We are to have 300,000,000 kw of utility and industrial power generating capacity in the country by 1968 or 1970, to power a population of well over 200,000,000 people and their industries. We look ahead to: Generating units of 500,000 kw capacity or even higher; steam generating units of 2,000,000 lb per hr capacity or more at supercritical steam conditions; developments in fuel burning and in industrial boilers; more gas turbines; advances in hydro power; the free-piston machine; better diesel engines. We will see more work in solar power; underground coal gasification; fuel cells or other methods for converting heat directly into electricity; heat pumps, more electric heating for homes and industry, more air conditioning; increasing uses of water; minimizing of air and water pollution; improved water treatment and industrial waste disposal. Future problems of electric transmission and distribution include use of higher voltages; the resurgence of direct-current transmission; developments in semiconductor devices, rectifiers, capacitors. Automatic control and communication developments, data processing, extensive use of computers, system control by automatic devices will lead engineers into problems now primarily in the field of economics.

New metals and other materials like PVC, new insulations and coatings, will lead to new designs. And finally, along with nuclear fission power plants, the young power engineer of today will see nuclear fusion plants — energy delivered to us from the sea.

Power engineering careers in both utilities and industrial power systems will range far and grow steadily, with expanded responsibilities. Young engineers will participate in all these advances, in a field just as glamorous as those of the jet men, the electronics men, the missile men. For underlying all is power.

Chester R. Earle

Editor, POWER ENGINEERING

These leaders tell you: A. G. Christie; Sabin Crocker; Calvin Davis; J. Gibb; Robert Jeffries; A. W. Kramer; E. H. Krieg; Edw. Moore; T. J. Putz; C. Schabtach; Irving Wade; Kenneth Watson; Robert Werden.

EDWIN H. KREIG — Vice-president, Stone and Webster Engineering Corp.

A Cornell graduate in Mechanical Engineering, Mr. Krieg has been active in all phases of power station work. After stints with Sanderson & Porter, West Indies Sugar Co, Ebasco Services and American Gas & Electric Co, he joined Stone & Webster as a consulting engineer in 1948 and as such has served many utilities. A Fellow in ASME, he has been a member of AIEE, NSPE and Prime Movers Committee of Edison Electric Institute for several years.

Design Trends . . . to man's ingenuity, a challenge

THERE HAVE BEEN many recent excellent papers on present day power station design so that the pattern for the next ten years or so is quite well known. The average size of turbine-generators now on order is about 130,000 kw with a maximum of 500,000 kw. These sizes are very likely to increase. Presently popular steam conditions of 2400 psi, 1050/1000 F for good load factor operation and high fuel costs are waiting on operating experience with supercritical units up to 5000 psi and 1100 F to indicate the scope of problems that must be overcome to achieve the desired 92 to 95 per cent availability. Research is under way to increase present transmission voltages of 345 kv to 460 kv or even higher, to handle the output of large units.

Increasing role of fission-fueled power plants has been well described in the technical press, and such plants may become competitive with fossil fuels, perhaps between 1965 and 1970.

Impressive Increases in the Industry

Future probable size of the electric power industry is impressive. Even if we have a decreasing *rate* of growth, the *yearly* growth is becoming very large indeed. Although electrical generation quadrupled during the ten years between 1902 and 1912, the rate of growth has decreased to doubling every ten years. However, the increase in *actual kwhr generation* per year is very great. From a generation of 2.5 billion kwhr in 1902, the industry grew to 11.6 billion kwhr in 1912. This contrasts with 600 billion kwhr in 1956 and 631 billion kwhr generation in 1957.

Large increase in capacity and generation per year brings concomitant problems posed by large units and stations of enormous capacity. Outages of very large units are costly, and few sites can be found to meet the needs of cooling water and fuel supply, as well as transmission rights of way. Today's challenge is the development of other means of power generation to avoid having sixteen 1,000,000 kw units in one station before young engineers now entering the power industry retire at age 65.

Boilers of very high capacity will bring increased need for higher heat transfer rates, but the high cost of "clean" fuel with high ash fusion temperatures to avoid bad slagging and boiler tube erosion will encourage the *opposite* trend to *decrease* heat liberation to avoid the cost of washed coal or premium fuels in the larger units.

Our foremost turbine engineers state that research efforts along present lines are bringing increasingly diminishing returns and that: "It seems appropriate to consider whether or not the large expenditure for research and development, which obviously will be necessary to realize this improvement, is justified." There is little question but that our progress in the economy of power generation is more dependent than ever before upon new ideas, and we may be sure that the electric utility industry will provide the necessary encouragement as it always has in the past.

To visualize the power generation problem forty years from now as merely an extrapolation of today's trends, has been aptly compared by Dr. W. F. Ryan, to an engineer in 1900 trying to forecast the growth of New York City, and then estimating how many horses it would take to carry 2,000,000 people to-and-fro each day. Then, after adding the additional horses and supplying the required hay and oats, the waste disposal problem would rival finding a home for waste products from nuclear power plants.

Possibilities of New Generating Methods

To asseverate that fission power is the cure-all for the increasing cost of power produced from fossil fuels, or that any other simple solution is in the making, would insult one's intelligence. Many avenues of approach are being made that do not at all resemble present power plant concepts. On page 6 of POWER ENGINEERING for November 1956, a 2 lb per kw power plant is described, consisting of a thin plastic material covered with a light-sensitive chemical over which a thin wire mesh is placed. "It is possible to obtain about 1200 kw of direct-current electricity for every acre of the plastic-wire mesh surface." Unfortunately, this only works in a vacuum. A recent Westinghouse release described the thermo-electric properties of ceramics, and includes the statement that "to date, our work with these new compounds is encouraging, and we have discovered no theoretical roadblocks to their expected usefulness . . . the day of useful, reasonably-large-scale thermo-electric power through these and other thermo-electric materials almost certainly lies in the not-too-distant future."

Summarizing — the immediate future of the industry does lie in the extrapolation of present trends, and we will continue to improve the economics of power generation by developing units of larger than 500,000 kw to operate at critical and even supercritical pressures. We will also have fission fueled plants with good economy relative to steam-electric plants in many areas. However, new and fresher ways of applying those principles are needed, as well as encouraging the blazing of new trails in present research programs. While so doing, let us beware of the problems raised by "feast or famine" ordering of equipment, bigness of stations, of scarce plant sites and transmission rights of way, as well as fuel transportation and water supply. While so occupied, we should watch what scientists are doing to develop new sources of power, perhaps without using boilers and turbines. Their work may well give a clue to more economic power generation in the U.S.A.

CARL SCHABTACH, Manager of Engineering,

Large Steam Turbine Generator Dept, General Electric Co.

A native of Buffalo, N. Y., Mr. Schabtach holds both BS and MS degrees in Mechanical Engineering from Cornell. He was employed by General Electric in 1933 and after three years in Advanced Engineering, joined the Large Turbine Department. He has been in his present post for the past ten years.

Turbine Generators . . . bigger machines, cheaper power

BULK OF OUR ELECTRIC POWER for many years to come will continue to be supplied by steam turbine-generator units, Fig. 1. With cost of power kept low, installed capacity can be expected to double again in the next decade. The challenge in these predictions will be met only through successful joint efforts of the equipment manufacturers, consulting engineers and electric utilities to minimize costs of plant, fuel, operation and maintenance, to provide the organization and facilities for growth and to develop new sources of energy. Capacity, efficiency, reliability and ease of operation of steam turbine-generator units are of major importance to low costs in the four areas mentioned. With respect to these, where do we stand and what may be expected in the future?

Capacity ratings, both maximum and average, have more than doubled during the past ten years. There are in service, Fig. 2, single-shaft tandem units rated 250,000 kw and a cross-compound of 325,000 kw. On order are 325,000 kw tandem and 500,000 kw cross-compound units, and machines of 50 per cent larger capacity than these should be feasible within ten years. In the generator, these capacity increases have become practicable only through the recent introduction and perfection of conductor cooling. With liquid cooling of the stator, output from a given physical frame size and weight of machine has more than doubled since 1948.

Lower Costs Through Larger Capacity Units

Increase in capacity has been a major factor in lowering plant costs per kilowatt. Future savings per kilowatt through continuing increase in unit capacity beyond that of the larger capacity units now operating appear small but, considering the large capacity and number of units involved, even these smaller gains amount to a very large reduction in investment.

Larger capacity units need larger turbine exhaust annulus areas. These may be provided either by longer last-stage turbine buckets or by more flows in parallel. Neither alternative appears to be generally better than the other and both are being developed.

Efficiency improvements have continued to come from use of higher pressures and temperatures, better steam cycles, refinements in the steam path and larger capacities. Historically, maximum steam pressure in use has doubled about every twelve years and temperatures have increased 12 F per year, Fig. 3. Ohio Power Company's Philo unit, which began operation almost two years ago with initial super-critical pressure steam conditions of 4500 psig and 1150 F, is still about on these historical trends. Its fuel rate is approximately 0.7 pounds of coal per kilowatt-hour as compared to the national average of 1.31 and 0.93 for the best station ten years ago.

Although the potential improvement in efficiency from each forward step in temperature and pressure is decreasing, substantial gains are still possible in larger units by going above today's common level of 2400 psig and 1050 F. However, the austenitic alloys required above 1050 F for some parts of the turbine, boiler and piping cost about three times as much as the ferritic steels being used at 1050 F and below. Thus, although steam conditions of 1200 F or more with pressures well above critical can be visualized, the economic soundness of adopting them widely in the near future depends on developments in materials research and on the ingenuity and resourcefulness of boiler, piping and turbine engineers in reducing the required amount of these high-cost materials.

Further Cost Reductions Are in the Picture

With re-superheating now employed in virtually all new installations, other thermal cycle improvements of comparable size are constantly being sought. Most promising thus far are combined steam-gas turbine cycles in which the gas turbine either exhausts into the boiler or operates on hot gas from the boiler which is supercharged by a compressor driven by the gas turbine. Two plants of the first type, totalling about 25,000 kw capacity, are in operation with a 4 to 5 per cent gain in heat rate over

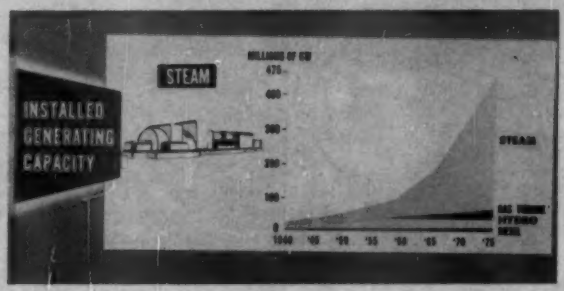


Fig. 1. Steam will continue to supply by far the greatest part of all electric power generation for years to come

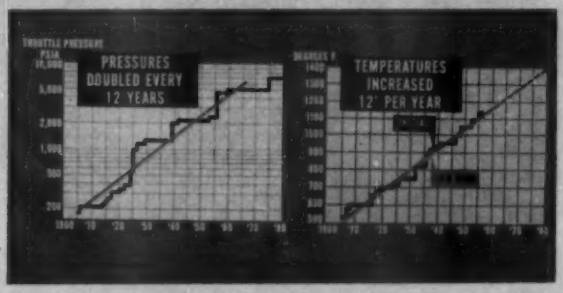


Fig. 2. Capacity ratings have more than doubled within last decade. Unit of 400 mw on single shaft is in design stage

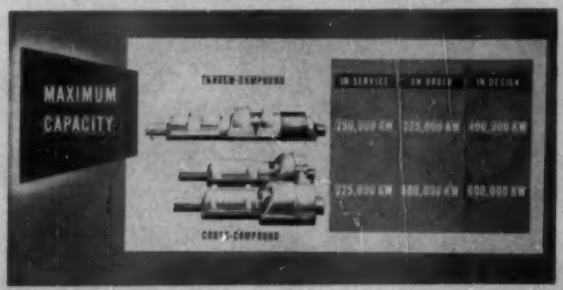


Fig. 3. Continued advance to higher pressures and temperatures will depend on developments in materials research

the straight steam cycle. Supercharged cycle is even more attractive, with gains of 6 to 7 per cent in heat rate and a possible reduction of about 50 per cent in physical size of plant over a conventional steam plant of the same capacity. Such installations must be limited to gas or oil firing until the problems of operating with coal are solved.

Reliability has been getting more attention as unit capacities have increased and as a few troubles have developed in recent installations of advanced design. Reliability determines the amounts of reserve capacity and spinning reserve which must be carried. Industry statistics show that the average plant outage rate, both forced and planned, is about 10 per cent; the forced or unscheduled outage rate of turbine-generators is about 1 per cent. Extensive studies of the value of this reliability indicate that if the current rate of 1 per cent were to be increased to 2 per cent, about 5 per cent more installed capacity would be required to maintain the present standard of service reliability; conversely, an improvement would permit a proportionate decrease in reserve requirements. Existing machines and the designs for new machines are modified promptly to eliminate sources of troubles which show up in service.

Reductions in operating costs and further improvements in reliability may, perhaps, be found in the field of automation. New developments are becoming available to the point where starting and stopping, normal operation and emergency operation of turbine-generators, and even whole plants, can be programmed and carried out automatically. Perhaps even more important than the savings in operating labor will be the savings in maintenance costs through the reduction of operating errors.

For operation on steam from nuclear reactors, numerous turbines are being built in ratings up to 30,000 hp for submarines and ships, in addition to the few larger units for electric utilities. Problem of excessive moisture in the turbine resulting from use of saturated steam is being met by using a moisture separator in the turbine crossover, plus ingenious moisture removal buckets which have proven their effectiveness by years of service in older non-reheat turbines. It is to be hoped that practical methods will be developed to superheat steam produced by nuclear reactors, to allow use of more efficient turbine cycles. This will be an economic problem of balancing the cost of the superheater against increased output and efficiency.

Development of the large steam turbine-generator, after 60 years, is far advanced but still far from complete. Larger capacities, higher steam conditions, greater internal efficiency, more advanced cycles and still simpler and more dependable operation continue to intrigue and challenge the imaginations of designers and operators. These elements will contribute to more installed capacity and lower cost of power. Progress will continue!

A. G. CHRISTIE, Professor Emeritus of Mechanical Engineering, Johns Hopkins University

Listing of Mr. Christie's honors and accomplishments fills a full half-page in Who's Who in Engineering. Educator, author, consultant to many of America's brightest industrial names, he edited the Steam Turbine Sections of Starling Marine Engineers Handbook and Kent's Mechanical Engineers Handbook, in addition to many technical papers and engineering articles.

Tomorrow's Boilers . . . larger units, thermal gains

ALL INDICATIONS POINT to the future construction of larger steam generators built for high pressure and temperature. Boilers, usually of the reheat type, of a million pounds of steam an hour are in service and larger ones may be expected.

Steam generator types vary from natural circulation units which can be used with pressures up to 2400 psi, to forced circulation boilers either of the controlled or once-through types. These latter types employ small tubes and are claimed to respond rapidly to changes in the rate of firing. Small tubes together with a small drum, or no drum at all, result in a substantial reduction in the weight of the steam generator. Such boilers will increase in numbers as operating and maintenance methods are fully developed and pressures increase.

Outdoor and semi-outdoor units are installed in southern sections while fully housed boilers are preferred for northern areas where heavy frosts are common. Such boiler houses are enclosed in the newer sandwich-type materials.

A number of steam generators have been installed for super-critical pressure operation with expected gains in efficiency largely due to increased steam temperature and reheat. Increased work of boiler feed pumps at high pressures offsets much of the thermal gain. Greater improvements in thermal efficiency can be expected from higher initial superheat than from higher pressures. An urgent need is the development of new, reasonably-priced alloys that will permit the use of still higher steam temperatures, otherwise temperatures will remain about 1000 F as austenitic steels are hard to fabricate and are expensive.

Twin and divided furnaces, common in large units, provide means for better regulation of initial superheat and reheat. High radiant type of box furnace is now the accepted design. With increasing use of once-through forced circulation boilers, horizontal forms of boiler furnaces may be developed to save the cost of tall boiler structures. Their increased floor space would not be a handicap with outdoor types.

Automatic soot blowers of both wall and retractable types should be employed as fuels of lower quality must be burned. Air is generally preferred for such soot blowers.

Trend Is to Greater Automation

One-boiler, one-turbine installations have led to changes in control equipment. Control instruments have been moved from the front of boilers and turbines to a central control room where all station operation is directed by a few operators. This results in a large decrease in operating staff but the remaining operators must be highly qualified. Television types of instruments are provided so that the control room operator can see his burner operation and also his water columns when used. Thermocouples placed at various points in the boiler, superheater and reheater and indicating on the control board, aid in the quick-starting of the plant and in adjusting for load changes. Computors to continuously check performance are being introduced at control centers.

Panel forms of superheaters, widely used in Europe, are replacing the staggered arrangement of tubes generally employed. Panels are claimed to be less subject to dust collection and slagging than staggered tubes. A portion of the superheater surfaces may be exposed to radiant heat and, when combined with convection surfaces, this aids in providing relatively constant steam temperature over a wide range of output. Reheater surfaces are substantially the same as for initial superheat. Increased radiant superheater surfaces will be required with further increases in steam temperatures.

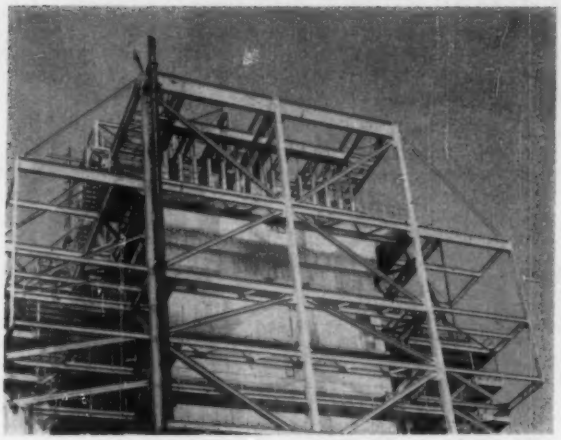


Fig. 1. Outdoor installations such as this million-lb-per-hour unit are common in areas where climate is compatible

Control of initial superheat and reheat temperatures is generally secured by spray desuperheaters although forms of attemperators provide good regulation without the risk of adding impurities in the spray water to the steam. Burner tilt also affords effective control of steam temperatures. Damper control, to secure differential gas flow over superheater and reheater surfaces, responds less rapidly to temperature changes than other methods.

Pendant superheaters in the top of the furnace or in adjacent gas passages are easily suspended and expand freely. These are not freely drainable, a desirable feature in semi-outdoor installations in areas subject to frost. Steam outlet from pendant superheaters is generally near the top of the unit. This requires long, expensive, high temperature steam pipes to the turbine stop valve. There appears to be a need for drainable superheater and reheater sections and for the arrangement of these surfaces so that the steam outlets are a minimum distance from the turbine stop valve.

Economizers, either of the plain or extended surface types, are comparatively small size due to the high feed water temperatures from the extraction heaters. Steaming economizers are no longer used.

Either tubular or Ljungstrom types of air heaters are installed in new power plants. These are generally designed to cool the flue gases to about 300 F. Since overall unit efficiency depends on the final temperature of the flue gases, attempts are being made to effect a reduction of flue gas temperatures by 100 to 150 F, and thereby secure from 2 to 4 per cent gain in station economy. Colder surfaces of the air preheater would be below dew point of the gases and would require stainless steel sections to resist corrosion. Condensation and dust collection on such surfaces would be cared-for by frequent washing with water while in service. Extra cost of such equipment may be justified by increasing fuel costs.

Social demands make it necessary to install dust collectors in coal-burning and even in some oil-burning plants. Combinations of mechanical and electrostatic precipitators are common in coal-burning installations. The satisfactory removal of dust from the surfaces of electrostatic precipitators has not been achieved. Rapping methods always re-entrain a portion of the collected dust which then passes out of the chimney. Such precipitators can stand further development to ensure less dust loss to the chimney. In plants where flue gases are cooled below their dew point, it will be necessary to locate the dust collectors up-stream of the air preheaters. Such dust removal will lessen deposits in the air preheater.

Evaporators provide make-up on low pressure plants but demineralizers are coming into general use with high pressure units. Automatic demineralizer control is necessary to eliminate the necessity for a chemist attendent of the demineralizer.

Coal will be burned in greater relative amounts as fuel oil becomes scarcer. Surface stripping and machine mining methods produce dirty coal of decreased heating values. Increased freight rates are contributing to the selection of plant sites at or near coal supplies when water is available. Fuels formerly wasted will be burned. Russians report that some coal with 40 per cent ash and other coal with 50 per cent moisture are being burned in some of their power plants. Similar fuels may be burned here in a few years.

Design Innovations Hold Costs In Line

Large deposits of lignite and sub-bituminous coal occur in various sections of the United States and Canada. These are being burned in new plants where their high moisture contents and snow and ice in winter, present new problems. Experience indicates that such fuels can be burned successfully when secondary air is furnished to the pulverizers at 700 F. Use of hot furnace gases for such mill drying is undesirable due to the risk of explosions.

Small coal bunkers, some with only ten hours supply of coal, are now used to lessen the cost of supporting steel structures and to decrease the risk of fire. Coal supplies may be withdrawn automatically by conveyors in tunnels under live outdoor coal storage piles, when needed.

Fuel oil will tend to increase in price due to restrictions on the importation of foreign petroleum supplies. Improved cracking and re-forming methods will also decrease available fuel oil supplies, and quality will also decrease since sulfur, vanadium and other impurities remain in the residual fuel oil.

Front, tangential and down-flow burners are in use with powdered coal. Cyclone furnaces seem especially adapted to coals with ash having low fusing temperatures. Pressurized furnaces eliminate the use of an induced draft fan and its maintenance.

Many dry and wet bottom furnaces have water-filled ash pits to disintegrate hot slag chunks. Sluicing removes ash from such ash-pits. Dusts from precipitators are sold for making concrete and for other purposes. When not sold, the dusts are wet down and used as fill.

Chimneys of increased height are being built to secure wide dispersion of the flue gases. Lined steel stacks appear to be preferred to concrete chimneys. An increasing number of chimneys are now designed for high exit velocities of the gases.

Trend in the over-all design of power plants has been towards the reduction of operating staff. This is achieved by increased instrumentation, automatic operation of equipment and centralization of all operation in a control room. Maintenance has also been lessened by improved designs. These factors together with better thermal performances, have prevented large increases in operating costs in spite of increasing prices for fuel.

Fig. 2. Superheater section of modern boiler as seen from furnace floor. Note panel arrangement of the superheater

CALVIN B. DAVIS, President, Harza Engineering Co.

A specialist in design of high dams and hydroelectric plants, Mr. Davis graduated from Drexel Institute in 1922. After serving as project design engineer of Fontana Dam for TVA, he joined Harza Engineering Co in 1947 as vice-president and, after five years, became president of the company in 1953.

Hydro Power . . . if it's big, it's practical

REVIEW OF THE HYDROELECTRIC power situation during 1958 would include reference to the remarkably high level of sustained activity in the industry, the trend to concentration on larger stations, and the advance of new forms of hydro power including tidal and pumped storage of energy. Despite continuing advance in the efficiency of thermal units and the advent of commercial atomic power, recent years have seen the accelerated development of hydroelectric power in the United States and abroad. The tendency has been based on the very cogent economic fact that good hydro power is still the cheapest source of electric energy available to man.

Certainly all the most favorable power sites in the country are by this time fully developed or being actively studied. During 1958, great strides were taken toward the development of our major power streams, including the St. Lawrence, Niagara, Columbia and Missouri rivers. On the Columbia, the "partnership program" of developing hydro is in full swing with the local Public Utility Districts taking the lead at Wanapum, Rocky Reach and Priest Rapids projects, which will add over two million kilowatts installed capacity to the national supply. Barnhart Island power plant neared completion on the St. Lawrence and work was started during the year on the redevelopment of Niagara Falls potential at Lewiston. More than two million kw of firm capacity will result from these developments. Niagara and St. Lawrence developments are being undertaken by the Power Authority of the State of New York.

In Arizona, the State Power Authority during the year has undertaken extensive studies of the development of the Colorado River for power in the reach between Glen Canyon and Hoover dams, but, of course, excluding the Grand Canyon Park area.

More Than Additional Power Is Involved

As in the past, many hydro power developments have represented parts of larger multiple-purpose river developments. Continued emphasis of this is evident in the developments of the Missouri and Ohio river navigation and power dams. Glen Canyon Dam on the Colorado River will yield extensive irrigation and flood control benefits. Projects on the Columbia river generally include provision for future lockage and will yield an immediate flood control benefit to the area.

During the year, realization of some of the more novel potentialities of hydro power came several steps closer in the U. S. Pasamaquody tidal power scheme, on which construction was actually started during the 1930's, was revived and is under active study by the Corps of Engineers. Potentialities of pumped storage hydroelectric energy to provide low cost peaking capacity was under active study by a number of private utility companies. One of the large companies, for instance, figures that a pumped storage plant costing $150 per kw of capacity and operating on the generating cycle only seven hours a day, with an overall gross efficiency of about 65%, is a more economical way to meet their peak demand requirements than the installation of new high cost, high efficiency system thermal capacity. In this particular case, the utility in question has exhausted its supply of peaking capacity from the older, less efficient steam plants and conventional hydro capacity already available to its system. Pumped storage schemes in North America favor lower heads and fully reversible pump turbines and in some cases adjustable blade units, while European practice has concentrated on high head developments with separate pump and turbine units. During the year, increased interest has developed in the probable future relationship of nuclear power capacity and pumped storage hydroelectric capacity. High capital cost of nuclear capacity would be spread over base load operations with low capital cost in instantaneous availability of the pumped storage capacity being utilized for the daily peaking periods.

In the foreign field, interest in the development of hydro power is at an all time high. Each underdeveloped country is thinking of the utilization of their river resources as one of the first steps of its industrial development program. A visit to the Brussels' Fair reveals that, even in this atomic age, every industrialized country is advertising prominently its hydroelectric equipment for sale.

During 1957, the world's largest existing hydroelectric plant, the two million kw Kuibishev plant on the Volga River was commissioned and Russian state authorities are planning and actually constructing a number of even larger hydro plants which will have even greater installed capacities. An example is the 3.2 million kilowatt Bratsk scheme on the Angara river in Siberia. During the last few years the annual rate of increase in power production from hydroelectric resources has averaged 14% in the Soviet Union. A similar picture could be drawn of many other areas of the world, including parts of Central America, Turkey, Iraq, Belgian Congo, India, Ceylon, Japan and Australia. The figures for Canada, I believe, are almost as high.

Some of the foreign countries, such as Switzerland and Austria, are rapidly approaching complete exploitation of their hydro power resources. It is said that if the present rate of development continues, Switzerland, for instance, will have totally utilized its rivers by 1980. In this connection, the world's present highest arch dam,

Hydro engineers must use every skill, effect many innovations as favorable sites become increasingly scarce

Mauvosin, was completed during 1958 and the dam soon to become the world's highest, Grand Dixence (it will be 920-feet high), was brought near completion in 1958. Projects are in southern Switzerland and are exclusively for power production.

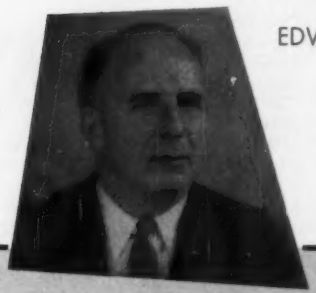
High Cost of Capital Presents Problems

It is interesting to note that certain large hydroelectric schemes involving very high capital investment came under reappraisal during 1958. Pressure to get quicker results with lower capital investment requirements through development of thermal energy resources was felt in many parts of the world. I have in mind the general slow-down in the Electricite de France development program, including at least temporary shelving of the pioneer Rance tidal power scheme. Premier Khrushchev announced that several of the high cost hydro plants in Russia were being "postponed" while Russia's industrial resources were channeled into endeavors which would show a quicker payoff. The huge Snowy Mountains hydro scheme in Australia advanced another step but not without allegations from some quarters that the power could be produced more cheaply from Australia's extensive coal fields and the water could be better used for irrigation than power.

Perhaps one of the most challenging events in the international hydroelectric picture in 1958 was the starting of final plans for the development of the world's largest hydroelectric project which will be located at Inga Rapids on the Congo River. This fabulous project, which has been under discussion since Stanley originally spotted the site almost a century ago, is located within twenty miles of Matadi, a deep water seaport, and appears capable of delivering the cheapest of bulk energy of any site remaining in the world — an ultimate installation of 28 million kw firm power at 1.2 miles per kwh generation and transmission cost is foreseen. An initial installation of 1.5 million kw is planned. Economic implications of this with regard to the refining of Africa's vast mineral resources will challenge the imagination.

For the future, I see a continuing development of hydro power in the United States and in most foreign countries. A few countries will approach full development and the remaining less economically attractive hydro sites will feel increased competition from the thermo and nuclear sources. However, the complementary relationship between nuclear capacity and hydroelectric pumped storage capacity appears to bode well for the hydro industry for many years to come in the United States. In all countries the development of the more efficient, longer distance, interconnected electric systems will permit more efficient utilization of existing large central stations. In foreign countries, this more efficient, longer distance transmission will bring new hydro plants into the area of economic feasibility. I have in mind a good example: the plants of Russian Power Authorities involving large hydro and thermal plants spread across 6,000 kilometers of Russia connected at first by 400–500 kv a.c. net work and eventually by an 800 kv direct current trunk line. They are also studying long distance 600 kv a.c. transmission.

One of the safest predictions with regard to engineering for hydro power in the future springs from the ever changing picture of technical development in the whole power field and increasing scarcity of favorable hydroelectric sites in our country and in many others. In this regard, I confidently predict that hydroelectric engineers will be called upon to utilize every skill, to effect many technical innovations, and possibly even to conjur a few minor miracles, in order to meet the incessant clamor for more and cheaper energy for consumers and for industry.



EDWARD R. MOORE, Manager of Engineering, The Detroit Edison Company

Mr. Moore, a native of Pennsylvania, graduated from Pennsylvania State College with a degree in Electrical Engineering. He is a Registered Professional Engineer in Michigan. Previously with General Electric, he has been with Detroit Edison for 32 years, becoming Manager of Engineering in 1955. He is a Fellow in AIEE, a member of the Engineering Society of Detroit, and a past president of the National Executive Council of Tau Beta Pi Association.

Generation and Transmission . . . definite factors influence trends

THERE IS little need to call attention to the persistent efforts of the electric power industry to devise means of combatting inflation by more efficient and economical means of power generation. Steam and electrical generator sizes have reached amounts that a short time ago represented the capacity of an entire plant. Double reheat, supercritical pressures, and binary cycles are among the expedients so far adopted or proposed. Further experience in these and other areas is being secured, although it appears that further gains will be at least difficult to attain.

The economic and technological factors influencing power generation trends today are numerous and more interdependent than ten years ago. Three factors currently of great importance are:

1. The effect of future nuclear power generation.
2. The relatively small improvement in system load factors.
3. The inflationary trends of investment and fuel costs.

In considering the first factor, nuclear power genera-

With a maximum interrupting capacity of 25,000,000 kva, these huge 345-kv circuit breakers are another step upward

View of the third unit of Detroit Edison's River Rouge plant. Rated at 321,500 kw, it is one of the world's most efficient

tion and its effect on long-range system planning, the prediction has been made that nuclear power will be competitive with conventional power in certain areas within ten years. Thus, the effect of installing a large nuclear unit with its high investment cost, but low long-range fuel cost and consequent preferential loading, is to "back off" existing highly-efficient conventional units and lessen the probability of economic justification for such highly-efficient units in the future. The effect of installing a nuclear unit will also influence the economic considerations involving installation of conventional units preceding a nuclear unit.

Consequently, a long-range program of generating additions to a system based on optimum economy may well be a nuclear unit, followed by conventional units before installing another nuclear unit. An occasional low-cost peaking unit addition may also prove economic due to its lower investment cost tending to offset the fuel cost penalty.

The second factor is important in the selection of steam conditions and thermal cycles for generation. High load factors aid in justifying added expense for efficiency improvement. Load factors vary between utility systems and this in combination with geographic variations in fuel cost may explain why one system can justify higher thermal economy than another. In making economic studies there is at present no general indication that there will be significant increases in system load factors.

The third influencing factor on trends is the inflationary cost of power plants compared with cost of fuel. Predictions are that power equipment costs will rise at a rate more than twice the corresponding rise for coal. This fact militates against the justification of high efficiency.

With system capabilities doubling in ten to twelve years, turbine generator sizes will tend to increase, although the economy in favor of larger units is diminishing as size increases. However, larger units will still result in slightly lower installed cost per kilowatt and lower operating cost per kilowatthour, due to a number of investment items which are not directly related to unit size; namely, land and development costs, turbine room and miscellaneous building costs, coal handling, engineering and design, and similar general items relating to any project. Careful consideration is in order in determining size versus potential outage penalties and reserve concepts. Also, the effect of the time required to start and load large units compared to smaller ones must be considered in selecting unit size.

Tandem turbine-generators are being built in the 325 mw size and 600 mw is considered possible, while cross-compound turbine-generators are being built for 500 mw size, with 1,000 mw contemplated. Close-coupled cross-compound turbine-generators reduce building volume, lower foundation costs, and result in more stable base design.

Studies have been made of the air-steam binary cycle where a gas turbine is combined with a steam generator. In systems where coal is the primary fuel, economic justification for this cycle is dependent on the ability to burn coal in a gas turbine. Lower exit flue-gas temperatures are gaining favor, one unit being now in operation designed for 206 F exit temperature.

The push toward supercritical pressure units has been slowed to some extent by economic factors, while the push toward higher temperature is contingent upon economics and more service experience with available materials, particularly for temperatures of 1100 F and higher. Double reheat has been planned for a few installations, while a secondary transfer medium for reheat is a possibility.

Most of the technological improvements outlined are available without much additional research and development. Their extensive application is dependent on economic justification, which may be retarded unless investment cost trends for these improvements follow more closely fuel cost trends.

Trends in Transmission

In determining a trend, it is always helpful to review the past, scan the future, and then determine whether what we see going on about us is consistent with these influences. Hence, in analyzing transmission trends, a look into these areas is indicated.

Insofar as the higher transmission voltages are concerned, greater strides have been made abroad than in the United States to date. These have resulted first from need, and then from an economic evaluation of the alternative methods available. In some instances, there appears to have been an impelling urge to develop means not at the time physically available.

Needs arose primarily from the existence of hydro resources remote from the load centers. Secondly, a need arose from the economic advisability to integrate, even across national boundaries, systems which were largely of hydro generation on the one hand, often with pronounced seasonal variations, and predominantly of thermal on the other. Still another factor involved the transportation of low-heat-content fuel as against generation at the fuel source.

In this country to date, the justification for extra-high voltage has arisen from the economic advisability of tying together a relatively far-flung system, the interconnection of two large systems for mutual reserve, and the transmission of some relatively remote hydro generation. Generation being predominantly thermal, it has been generally possible to locate it relatively close to its utilization, giving rise to systems that by comparison are closely knit as to generation and load.

One factor of increasing importance is the increasing cost and limited availability of necessary transmission rights of way. This condition exists importantly abroad also, and is reaching major proportions in this country. Economic considerations, therefore, are becoming almost secondary, and an imperative need for minimizing to the maximum extent the number of rights of way is becoming the prevailing consideration. Public opposition is probably the major obstacle.

Economic justification does prevail, however, in the selection of the voltage level to be used. Relatively few systems have found it economical to utilize the highest prevailing EHV developed in the United States — 345 kv. Increasing consideration, however, is being given to this voltage, primarily because equipment of the characteristics and capabilities necessitated by the large compact systems of this country has been developed. Parenthetically, it is unfortunate that American and European development did not occur at a common voltage level.

Conditions on some systems, at least for the foreseeable future, may not justify adoption of a transmission voltage of this level. Similarly, consideration of high-voltage direct-current transmission would appear at the moment to be applicable particularly to situations where overhead transmission of any description would be impractical. Hence, the adoption of somewhat lower voltages, attractive because of lower cost and minimum radio interference problems, may for the time being exceed in total the adoption of 345 kv and higher.

Acquisition and utilization of rights of way present a problem in still another area. Unless provision is made in the initial acquisition, or the right of way is secured in fee, the initial construction of a transmission line designed for

a lower voltage, later to be replaced by an EHV line, may necessitate renegotiation when the time comes to construct the EHV line. Forecasting of ultimate need, the initial acquisition of rights of way of adequate width, and erection of towers designed for the ultimate EHV, with conductors and insulation for initial operation at a lower level, may be indicated.

Pipeline transmission of coal, economically desirable to combat the constantly increasing costs of rail transportation, would appear to have limited application in its present state of development. It would appear also that economics will in some cases indicate the preference for generation at the fuel source, and transmission of the energy over a reliable system of EHV construction.

On a smaller, compact system, economics of generation and transmission combined may justify EHV transmission tying together the relatively distant and dispersed generating plants through an EHV loop, with radial lines of a lower voltage distributing into the load areas. This would facilitate, and to a considerable extent justify the operation of generating equipment most economical for the load prevailing from hour to hour, day to day, and season to season.

In summary, it would appear that systems in the United States are being guided by the needs peculiar to their conditions, and those responsible for making the decisions are not being carried away by a desire to be among the first to go to EHV levels. Recognizing that any attempt to predict the future beyond what is presently indicated would be futile, the various high-voltage research and development projects now under way are certainly essential for that time which is at present over the horizon. Effects on transmission systems that may result from problems peculiar to the choice of plant sites for nuclear generation also must be kept in mind. It is only good judgment to prepare now, particularly in the acquiring of transmission rights of way, for the conditions which may arise in the future.

ROBERT J. JEFFRIES, President, Data-Control Systems, Inc

President of the Instrument Society of America, 1957–58, Robert Jeffries has a wide background as an electronics and instrument engineer. His work has affiliated him with the Systems Research Laboratory of Johns Hopkins University, the National Bureau of Standards, Army, Navy, and many others.

Instrumentation . . . systems engineering is the newest and least understood

RECENT YEARS HAVE seen the field of instrumentation emerge as a new engineering science. In the last year in particular, it has become apparent that instrumentation embraces four fundamental concepts which are inherent to all its forms and uses. These are: 1. measurement; 2. data-handling and computation; 3. control; and 4. systems engineering.

Measurement, taken in its broadest sense, is the detection of a quantity in which one has an interest, and the assignment of a magnitude to that quantity, based on some reference standard. Usually we say that the detection aspect of measurement is accomplished by means of a senser. This is a derivative of the medical concept of sensory organs.

The function of data-handling and computation is a second common denominator of all instrumentation systems, and one by which the system modifies or operates on available data so as to yield or present it in the most useful or readily assimilated form. It may involve conversions from one form of energy to another; for example, from mechanical displacement to electrical voltage, from one language to another, as from continuous or analog-type signals to digital, and from raw data such as costs and income to derived quantities such as efficiency and net profits.

The third common denominator is control. Automatic feedback control is the superposition of corrective actions on a system until the error is reduced to an acceptable minimum.

Systems engineering is the design and synthesis of a successful system; that is, the matching of the characteristics of the measurement capability, the data-handling and computation function, the controller characteristics, including its criteria and alternatives, to the plant or process — and the matching of all of these to achieve an optimum performance in relation to the desired end result. Systems engineering is the newest and the least understood common denominator of instrumentation.

Measuring devices, data converters and computers, and controllers are the equipments of instrumentation.

Perhaps the greatest potential for systems engineering lies in the concept of the development and operation of production centers in which the variables of the process and of the market are continuously integrated into a continuously computer-directed operation. But before this can be achieved we must and will see the development of:

1. Better dynamic means of measurement and analysis.
2. Completely new concepts of processing units, such as crushers, grinders, evaporators, heat exchangers, fractionating towers, condensers, machine tools, etc, designed principally to maximize their dynamic response, and thus their controllability.
3. Better understanding of the economic dynamics of the business and the market. This will involve mathematical models of the plant and market, and their interrelationship, in which the variables will be business measures, such as profits, efficiency, inventory, return on investment, demand.

Computers are among the equipments of instrumentation. This one is used by Gulf Oil on complex process problems

ROBERT G. WERDEN—Principal, Valley Engineering Co

Valley Engineering Co was formed by Mr. Werden to specialize in the design of heat pump and electric heating systems—for utilities, manufacturers, architects and other clients. A graduate of Lehigh University, Mr. Werden is credited with development of the compound or multi-stage heat pump

Heat Pumps . . . hold great promise in refrigeration and air conditioning

AIR CONDITIONING AND REFRIGERATION may generally serve different segments of the temperature spectrum and therefore seem to be related. Although many feel that air conditioning may have sprung from refrigeration, it just might be that developments in both fields are currently suffering from a sort of isolation.

The author hopes not, but it does seem that other fields of engineering have developed, technically, far more than refrigeration or air conditioning. Consequently, the public seems to enjoy benefits from other technical fields to a much greater degree.

This may be the very reason why the fields of refrigeration and air conditioning probably offer as great an opportunity to engineers and manufacturers alike, as any of the newer areas of applied engineering.

The post-war demand so overloaded development and application engineers with the mundane task of filling orders, that little time and thought has been given to the prospects for the future. To mention just one potential, with less than 5 percent of the nation's homes air conditioned, the industry is faced with the appalling fact that last year's percent saturation of air conditioned homes declined. Housing starts, in what was predicted to be an off-year, still were great enough to cause the percentage of air conditioned homes to decline.

Although air conditioning of commercial buildings and trade establishments seems to be accepted by all, there is an even richer future ahead in the air conditioning of industrial plants — both for increasing worker-efficiency, and for improving the quality of the manufactured product. In transportation, schools, churches — everywhere — the public is seeking out those places where comfort can be had.

One needs only to consider the tremendous cost of food-distribution to realize what improvements in processing, transportation and storage refrigeration could mean in benefits to mankind.

Add to this the requirements of the rapidly growing chemical, petroleum, and bright new solid-, and liquid-fuel industries, and it is easy to see that the refrigeration industry must take some giant steps to keep pace.

The past few years have, however, brought forth some very worthwhile contributions. The development of the hermetic compressor, in both the small and large sizes, is probably the greatest improvement. Although a modification of the previously established *open machine*, the hermetic unit has materially reduced field service, thereby bringing trouble-free operation to those who do enjoy refrigeration and air conditioning benefits. (See Figures 1 and 2)

The improvement of the absorption cycle, using water-vapor as the refrigerant, is another major contribution.

Then, too, many manufacturers now build package-systems. By assembling components at the factory, large equipment (formerly built up in the field) now requires less space and eliminates many hours of costly field labor. The chances of field installation errors are also greatly reduced.

In the field of air-distribution, the use of higher velocities (and the induction principle) greatly reduce the space requirements. The latter provides extreme flexibility in the control of both temperature and humidity of the air conditioned space.

In this regard, it is the author's opinion that as more and more people become exposed to air conditioning, they will be much more discerning. That is to say, yesterday they were happy just to be cooler, but today they demand the ultimate in year-round temperature, humidity, filtration, odor-control, noise-control, and air movement.

This is human nature. The "tin-lizzie" auto was fine until we experienced something better. And, although the *purchasers* of commercial and industrial air conditioning are plant owners, the *users* are the public and the individual. This is the root of the problem; the owner is cost-conscious as he is making a capital expenditure, but the occupant is a different person and is only motivated by satisfaction.

In other fields of the power industry, engineers are employing increasingly greater amounts of energy. Increased lighting intensities (100 fc is commonplace and applications of 300 fc are being made); higher wattage and increased densities of electronic business machines; greater concentrations of power equipment in industry — all increase the internally-generated heat in buildings. This has reached the point where heat leakage through walls and roofs has become the smallest component of the average commercial and industrial air conditioning load. Manufacturing plants, formerly cooled by ventilation,

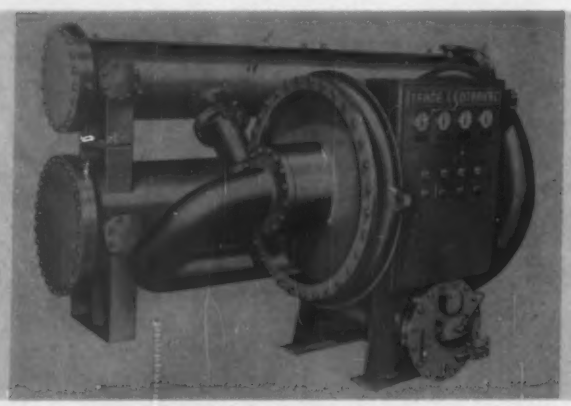


Fig. 1. Type of large hermetic refrigeration unit. Sealing motor and compressor cuts maintenance. (Photo by Trane Co)

Fig. 2. Shown here is small hermetic unit. This type used for packaged equipment. (Courtesy York Divn—Borg Warner)

are finding the need for air conditioning by mechanical refrigeration.

But, are the engineers working in unison? The lighting engineer is applying more energy which multiplies the need for still more energy to run the air conditioning plant.

What is the solution to this problem? *The most practical answer lies in the heat pump.* For instance, the same additional 100 kw of lighting (that requires approximately 36 kw more for refrigeration compressors, fans, and pumps) REDUCES the winter heating load by 341,300 Btu per hour.

All this leads to the conclusion that the heat pump, even for minus 10 F. climate, is becoming more feasible. The increase in internal loads is rapidly bringing the summer cooling, and winter heating, in easy reach of the heat pump.

On larger commercial and industrial air conditioning systems employing multiple compressors, the development of the compound heat pump (two stage-parallel in summer, series in winter) has greatly improved the efficiency of the system. Many large installations today are completely heated with the heat pump, using only outside sub-freezing air without any supplementary resistance heaters, even in minus 10 F. design areas.

The heat pump holds much promise in other applications. Many process plants are cooling in winter and discharging the heat to the outdoors. Simultaneously, steam is being generated to provide heat for other process lines or for space heating. This is obviously wasteful. Why not capture the heat rejected from the process cooling, transfer it by heat pump, and deliver this "free" heat to a needed area?

Recently, the author heard of a large warehouse, just constructed, that illustrates this concept very well. The designers had applied multiple-cooling units along the outside of the cold storage portion, discharging the rejected heat to the outside. In winter, steam was being generated to heat the adjacent dry storage area. The heat of the dry storage, passing through the insulated partitions into the freezer areas, required refrigeration, which rejected the extracted heat to the outdoors. This seems quite conventional, but it provokes the thought that heat generation costs money; in this case the heat was being thrown away, indirectly. Does it not seem more practical to take the heat rejected by the refrigeration plant and transfer it by a heat pump to the dry storage area, thereby reducing and perhaps in some instances completely eliminating any need for a conventional heating plant?

In large multi-zone buildings, heating is often required in some spaces when cooling is needed elsewhere. True, this cooling has generally been accomplished by opening outside air dampers, so that up to 100 percent outside air provides this cooling. However, the author's firm is currently designing such a system, with the outside air dampers at the *minimum* position. Then mechanical-cooling, applied to the zones requiring cooling, will transfer the heat by heat pump to spaces still requiring heat.

In this way, heat from internal or *core* areas is transferred to the exterior where heat is needed.

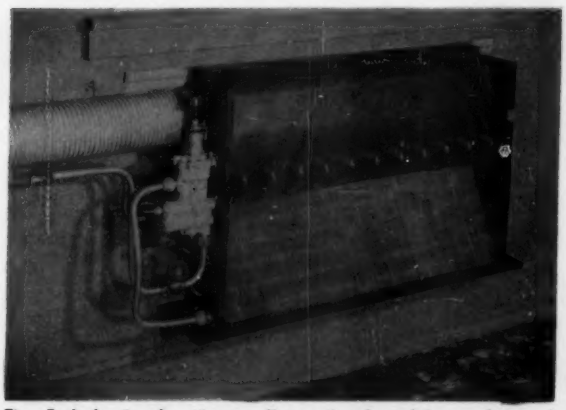


Fig. 3. Induction heating-cooling unit, placed in conditioned area (Front cover removed. Courtesy of Carrier Corp)

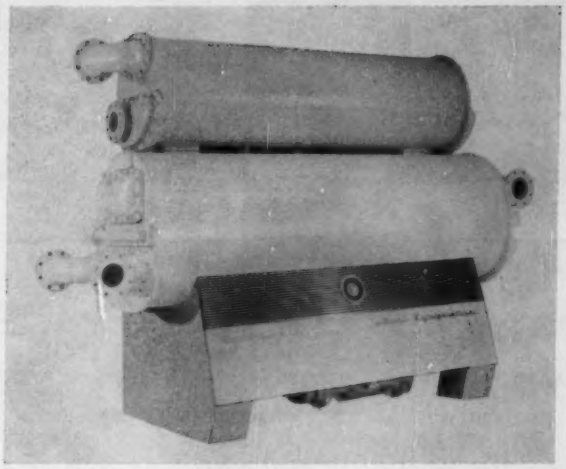


Fig. 4. Absorption-type of refrigeration unit; utilizes water vapor as refrigerating medium. (Courtesy of Carrier Corp)

In heat-transfer in chemical plants, heat-exchange (or regeneration) has generally been limited by the terminal temperatures of the fluids. Heat pumps offer the exciting possibility of greatly increasing the range of cooling and heating at much less cost.

Heat pumps offer the electric utilities the hope of bringing summer and winter demands into balance.

Smoke abatement problems are eliminated with heat pumps, and insurance rates may be reduced when combustion is not present in the building.

Engineers should carefully study the possibilities of the heat pump principle as a solution to more applications. Although the well of conventional-energy fuels has not run dry, perhaps it is the engineer's responsibility to to conserve what energy we have for the future. The need to control energy sources is constantly sparking international politics. A major portion of the world's supply of oil is used for heating. Perhaps heat pumps, utilizing electric power from hydro plants and atomic power plants, may be one way to conserve what energy we have.

Regardless, the author feels the time has come for refrigeration, air conditioning, and heating and ventilating engineers to scrutinize their designs very carefully. They should be alert to possibilities of recovery of heat from wasted exhausts; conserve energy wherever possible.

Solar-energy collectors, in one form or another, still need considerable refinement; but they, too, offer exciting possibilities for the future, either separately or combined with the heat pump.

Thermal electric systems employing the Peltier effect are in the advanced laboratory stages; in years to come they may fill a need for a compact cooling unit.

In conclusion, it is well to further emphasize the desirability of making heat-balances. The author, recently participating in a seminar with other engineers, discussed heat balance, waste of energy, and heat pumps. Among the many problems explored, here is just one pertinent and thought provoking idea: —

Engineers can labor for days on end to provide a design which management takes for granted. But accountants and lawyers have outshone them, with such legislation as the *tax credit for depletion of natural resources.*

Why then, if natural resources of energy can be saved by recovery of waste heat with heat pumps, shouldn't the careful engineer be credited too? Perhaps the government should give the capital-investment in an air-source heat pump equal tax credit. After all, a real conservation of natural resources can be had by employing a heat pump using "free" outdoor-air as an energy source.

Although the refrigeration and air conditioning industry has brought forth some splendid developments, they have been, to a large extent, refinements of equipment, and principles of many years standing. What is needed now is a thorough and complete exploration of the application engineering of these two industries. The future will then be bright and without limit.

KENNETH S. WATSON, consultant,
Water Management and Waste Control, General Electric Co

Kenneth Watson is a graduate of West Virginia University with B.S.Ch.E. and M.S.Ch.E. degrees. Before joining with General Electric, he was a member of the Interstate Commission on the Potomac River Basin, and also a member of the Ohio River Valley Water Sanitation Commission. He served as 1957–58 president of the Federation of Sewage and Industrial Wastes Associations

Water and Waste Control . . . more cooling towers, spray ponds, condensers

INDUSTRY IN RECENT years has become more concerned with the relationship between plant operations and water supply. This is true because in many areas water is in short supply. Water is also consistently increasing in cost, as the nation's water requirements grow, so it must be used wisely. Finally, sound water usage is the first step in simplifying liquid wastes problems, and most industries are attempting to be good corporate citizens and solve such problems.

In the increasing trend toward water management in industry, a number of approaches are paying dividends. More plants are making a specific assignment of the responsibility for water usage and waste control. More within-the-plant water meters are being installed, so that actual usage for important operations is known. Simple, inexpensive conservation steps are being more widely practised. More cooling towers, spray ponds and evaporative condensers are being used, permitting water to be used over and over again.

Wastes Control

Vital importance of the nation's water resources is being more fully realized by everyone. Industry is no exception. Primary step in protecting this resource is that of providing sewage and industrial wastes treatment plants. For the most part, industry is keeping pace with the pollution control program of each state by building necessary treatment plants to correct plant waste problems.

Some of the waste problems in industry are quite complex, making it important that laboratory studies and pilot plant work be completed before the treatment plant is designed. Liquid wastes treatment facilities are also quite costly, running from 2 per cent to 8 per cent of the total cost of new industrial plants requiring waste treatment. There are still some types of industrial wastes for which no economic treatment answer has developed, in spite of considerable research.

Industrial wastes treatment facilities vary widely from simple limestone neutralization beds to complex chemical and biochemical treatment units. This means that industry must be sure that the treatment facilities planned are tailored to the specific problem. Detailed coöperation with city officials and control agencies is also indicated so the regulatory people will not insist on non-productive cost treatment facilities beyond the minimum necessary to solve the problem.

Industrial experience in liquid waste treatment to date bears out the fact that a sound approach has crystallized for the handling of waste problems. First step in this approach is that of completing sufficient survey work to define the problem. The second step is one of carrying out economic, within-the-plant, short-of-treatment steps to reduce the problem to a minimum one. Final step is one of designing, building and operating the waste treatment facilities to correct the minimized problem.

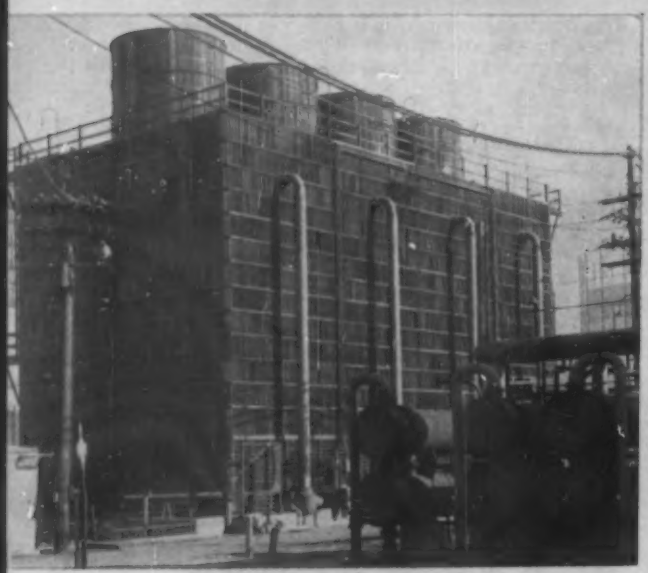
Air pollution control is not as fully advanced as is the field of water pollution control. Atmospheric problems are not canalized, however, and more people in an area are aware of them than is the case with stream pollution problems. Progress in Los Angeles, St. Louis and Pittsburgh indicates that the local area approach is probably the best method of solving air pollution problems. Meanwhile, a number of states have ratified air pollution control laws and many more are considering such action.

It is apparent in this type of climate that industries with a potential atmospheric pollution problem should launch a survey to define the magnitude of the problem. With such a survey completed, the plant would then be in position to move when a program embracing the entire community is launched.

Future Programming

Looking ahead to future action in the water management and waste control fields:

1. Industry must give more consideration to sound water usage in all plant operations.
2. The reuse of water, including the effluents of industrial wastes and sewage treatment plants, must be factored more fully into industry's future thinking. A number of industrial plants are at present using the effluent from sewage treatment plants as a source of industrial water supply.
3. Industries, municipalities and private citizens must think more in terms of the most economical treatment approach for an entire area. In many cases this will represent common collection and treatment facilities with industry tying into the common system, sometimes after pretreatment.
4. In the location of new plants, industry must give more thought to the adequacy and cost of water supply and to the waste treatment required for both liquid and atmospheric discharge and how expensive it will be.



Cooling tower at Atlantic Refining Co's Philadelphia refinery plays a major part in water-quality-control program

THOMAS J. PUTZ—Manager, Industrial Gas Turbine Dept, Westinghouse Electric Corp

Mr. Putz is a graduate of the University of Illinois in Mechanical Engineering, and is a Registered Engineer in Pennsylvania. He is a member of the Executive Committee of the Gas Turbine Power Division of the American Society of Mechanical Engineers, and was chairman of that division in 1957.

Gas Turbines . . . versatility, economics point to a brilliant future

IT IS CERTAINLY timely to review the status of gas turbines to see what place they have taken in the power engineering picture. Have they completely replaced other types of prime movers in their capacity range as had been predicted by their more enthusiastic proponents; or have they fallen by the wayside as their glamour wore thin as had been predicted by their detractors?

Facts are that the progress made by this new prime mover has been far better than could have been reasonably expected. The past five years have seen the gas turbine become an established prime mover of modern industry, no longer considered experimental. In this period the number of units has quadrupled and now totals over 450, with an installed rated capacity in excess of 3,500,000 horsepower.

Applications are divided into two major categories, mechanical drives and electric power generation, with the former outnumbering the latter by a ratio of approximately two to one.

Mechanical drives are used to drive compressors in gas and oil pipeline transmission, oil-field pressure maintenance, petro-chemical applications, blast-furnace blowing, refinery applications, and marine propulsion.

In the field of electric power generation there are approximately 140 units installed with a total capability of 1,400,000 kw. The average capability of this group is 9000 kw. The largest unit in service is 27,000 kw and the largest now building is 40,000 kw.

As would be expected with the introduction of any new prime mover many difficulties had to be overcome. Many of the difficulties resulted from over-enthusiasm of its more ardent proponents to have the gas turbine outperform other developed prime movers on all counts. In some cases this resulted in complex unit arrangements with cumbersome heat-transfer equipment, in others with complex fuel systems, with still others burning poor grades of residual fuels and coal. It became apparent that many of the advantages of the gas turbine were lost when the gas turbine was asked to do more than could be reasonably expected. Experience has shown that additional development is required to realize the proper advantage of the more complex cycles.

Today, the simpler, proven gas turbine is an excellent prime mover when properly applied. In areas where its unique advantages of small size and weight, portability, and freedom from cooling problems can be utilized, it surpasses any other known power plant.

Variety of Fuels

Earlier reports led one to believe the gas turbine could use any type fuel from sawdust, to peat, to coal, to oil and gas. The facts are that while it is possible to utilize some of the lower grades of fuel, this can be done only by increased maintenance. Gas has proven to be the ideal fuel. Wide ranges have been used successfully — from the lowest blast-furnace type to the high-heat-value tail gas of refineries. Turbines have been operated for years accumulating thousands of hours of trouble-free service using gaseous fuels.

Distillate oils have also been used with success. Residual fuels with vanadium and sodium ash have proven troublesome. Early efforts to use these fuels with such ash resulted in excessive hot-ash corrosion and fouling of turbine parts. Methods have been devised to overcome these problems by treatment of the fuel oil. Such treatment equipment currently becomes a part of the gas turbine fuel system. As the market for this type fuel increases it will be possible for the supplier to process the oil more efficiently and therefore make this type fuel suitable for even the small gas turbine units which today cannot justify the required fuel treatment system.

With solid fuels the problem is to overcome the hot-ash erosion of turbine blading. Fly-ash separators have been developed that appear to have solved the problem. However, in the small capacities the economies of such equipment with the current relative coal and fuel oil prices does not appear justified.

In addition to the fields where gas turbines have established themselves it appears that the following applications lend themselves to the advantages of the gas turbine cycle.

Integrated Process Applications

As the petro-chemical and other process industries continue to develop, gas turbines can be arranged to supply power to drive compressors, and/or extract high-pressure air or hot exhaust gases, separately or in combination. The ability of the gas turbine to utilize a wide variety of fuel, often process gas, and to be integrated into the heat cycle, can result in maximum overall thermal efficiency.

Electric Power Generation

Base Load Plants — In this field the combined steam and gas turbine cycle can improve plant efficiency approximately 4 to 6 per cent over a comparable steam plant. When used to supercharge the boiler it results in a smaller, more compact power plant which should have a lower first cost.

Peaking and End-of-Line Service — For the gas turbine to become a greater factor in this field in the US will require development of larger units. As experience is gained with present gas turbines it appears that the present single-flow units can be arranged for multiple-flow arrangements. This would result in units of 50,000 kw and above, which would be most attractive to utility power generation provided their first cost can be kept low.

Closed-Cycle Turbines with Nuclear Heat Source

A unit of this type is now under development for the AEC and the Maritime Commission. This type unit offers considerable advantage in increased efficiency and can be made in larger power ratings. The long-term potential of this plant is keyed to further development of high-temperature gas-cooled reactors.

Shop photo of gas turbine and compressor ready for shipment illustrates its advantages in compactness and portability

IRVING L. WADE,
General Superintendent of Generating Stations, Commonwealth Edison Co

Irving Wade was born in Illinois, and received his B.S. (ME) from the University of Wisconsin in 1923. He went into the Public Service Co of Northern Illinois after graduation, and when that company merged with Commonwealth Edison in 1952, Wade was made chief of generating stations. In 1955, he received the University of Wisconsin's Distinguished Service citation.

Power Plant Management . . . increased importance for employe relations

RISING COSTS OF equipment and labor create the necessity of finding ways to buy and to arrange equipment so that a minimum of manpower is required. One means to this end is the use of larger units of equipment. In the past ten years the maximum size of turbine-generator units ordered has increased from approximately 150,000 kw to 500,000 kw. Some improvement in economy has been obtained with the larger units but, equally important, the cost per unit of capacity has been reduced and, generally, it has been possible to operate them with no more men than are required for smaller machines. With this trend the ultimate maximum size of units is hard to predict and is mainly limited by the manufacturers' facilities.

The same economic conditions have encouraged the use of more automatic and remote controls. With present equipment there seems to be no limit to the size of boiler or turbine generator that may be controlled by one man from a single control board. The question of how many other men are needed for operations is a question only of providing men for starting unit components and to detect the unforeseen events for which it is not possible to provide control room indication. The starting of large units is an infrequent event and is often taken care of by bringing operators in on an overtime basis. The number of men required for insurance against upsets is a matter of judgment and there is no general agreement on the matter. Fire protection and employe attitudes are factors to be considered.

Many companies are considering further automation consisting of automatic starting and stopping of equipment, automatic logging of data, and computers for providing immediate efficiency results. The advantages of this additional equipment must be balanced against the additional investment cost and manpower required to keep such equipment inspected and maintained.

There is no trend in power plant management more significant than the increased importance of employe relations

There has been a trend toward the use of less spare equipment in order to reduce investment. This also reduces the reliability of a plant unless there is an increase in the dependability of the components. Design and manufacture of these components have improved, although hindered by the necessity of producing the rapid increase in sizes. Better planned maintenance is also required to insure continuity of service.

Single boiler turbine-generator units are now being purchased almost exclusively. This creates the problem of providing the required number of maintenance men for overhauling of all the associated equipment during an outage of the prime mover. The extra fuel cost to the system due to having the more efficient units not operating may amount to $15,000 per day. This requires that overhauling be conducted as many hours per week as possible, and with as large a crew of men as can be efficiently utilized.

If work is carried on by two shifts working 60 hours per week a crew of 100 men can be used. All of these men must be kept busy during periods of no major outage, which may be 75 per cent of the time for any one year. This requires ingenuity. Some companies solve the problem by using a roving crew which is shifted from plant to plant as needed. Others cover most of their maintenance by a central system maintenance department. Some borrow men from other plants for their peak maintenance. All of these involve problems of distribution of overtime payments, promotional seniority, or other forms of premium pay.

Costs and Their Comparison

Cost accounting and budgetary control become more important as a power system expands. In the closer examination of the economics of replacing old equipment, of the need for new equipment or of the design of new equipment, the question must be answered as to the cost of operating and maintaining present equipment. No system of cost accounting can reach a greater accuracy than the accuracy by which the men doing the work account for their time. The need for more details of costs introduces a complication of accounting not easily understood by the average power station operator. There is room here for more modern methods of recording original details in order to avoid errors and to save clerical time.

In comparing costs of operating and maintaining several plants of a single company operating under the same wage rates, general rules, and policies, it is very difficult to determine the reason why there is not more uniformity of results. Many different comparisons are attempted, such as cost per kwh, cost per kw of capability, cost per units of equipment, etc. None of these gives the complete answer as to what minimum costs should be. It takes a great deal of judgment and knowledge of local conditions to point out where costs might be reduced. The variations in type and arrangement of equipment combined with the long-time cycle of maintenance costs make this difficult.

In any company where most employes enter the company through the lowest grade jobs, a large program

of training is required. It is the policy of most utilities to fill better jobs by promotion. This means that the most qualified men are picked, started at the bottom and trained for higher positions, putting quite a burden on the first-line supervisors in performing on-the-job-training. Also, due to seniority rules, not only are the most capable men trained for promotion but an effort is made to train *all* the men so they may rate promotion. This is no easy task. Various forms of rating sheets have been used to plot a man's progress and, in certain classifications, oral examinations are required.

It is especially difficult to train and classify mechanics, since it requires planned programs of diversified work which seldom fit into the daily maintenance program. The most valuable mechanic on maintenance work is the one who can diagnose trouble and correct it. This is a trait hard to train into a man not so gifted. Better schools for mechanics can be developed but they are expensive to operate.

As each new generating unit installed is usually a tailor-made job, with different makes of equipment and controls from previous units, it is necessary to conduct a rigorous training program for operators of the new equipment. This starts with the writing of instruction manuals by plant supervisors and is followed by class-work and demonstrations. The preparation of the manuals, which serve as a perpetual reference for old and new operators, costs as much as $25,000 for a single unit. The results of such training indicate the money is well spent.

Load Control

As a power system grows, new units are added to carry the load. Methods used for controlling and distributing the load from a few machines become inadequate when there are 20 or more units involved. Calculations of the right loading for each generator can no longer be made with the speed necessary to obtain the greatest efficiency. Many companies have purchased some form of automatic load-control equipment. There are many types available which give various degrees of control.

One of the most complete controls purchased is for a system of more than 60 generators and continuously applies the principle of "least incremental cost" to 35 generators. As tie-line loadings or frequency changes demand, signals are sent to the generators to pick up or lower generator outputs. These signals are automatically corrected for transmission losses to load centers.

Justification for the cost of this equipment is the savings in fuel from always having the optimum distribution of load and being able to maintain the desired frequency and tie-line loadings.

Employe Relations Are All-Important

There is no trend in power plant management more significant than the increased importance of employe relations. The need for efficient and economical operations creates situations, many times, not entirely satisfactory to the employes. These situations may break with tradition, may involve larger equipment, more remote and automatic controls and result, often, in an actual excess of manpower. Collective bargaining agreements may be involved.

To cope with this requires a thorough understanding of the agreement and a training in human relations for first-line supervisors on up to top management, not considered necessary a few years ago. More and more time must be spent by management in looking and planning ahead to avoid as many disputes as possible and in settling those which do arise. This offers a challenge to engineers to be able to combine their technical training and mechanical and electrical equipment experience with an ability to understand and cope with human reactions.

Finally, the Atom

Then for some of us there is the thrill and challenge of a new type of energy for generating power — nuclear energy. Having lived through development periods of stokers, powdered coal, oil and gas fuels, cyclone furnaces, steadily increasing steam temperatures and pressures, and increased sizes of units of equipment, this new type of energy comes at a time when there are no other startling developments in sight.

Those who are fortunate enough to have a part in this early stage of development in the use of nuclear power for the generation of electricity will obtain much personal satisfaction and will have participated in solving the many problems which always accompany new concepts. Numerous schemes have already been proposed for converting nuclear energy into electric power and the possibilities seem limitless. The years of experimenting which lie ahead offer wonderful opportunities for scientists and engineers. New problems and new hazards require new techniques and training to meet the complications of this new form of energy.

ANDREW W. KRAMER, Editor of ATOMICS

Andy Kramer, formerly editor of POWER ENGINEERING, has been actively concerned with nuclear power development for over 13 years. His book, Boiling Water Reactors, was one of the 13 prestige volumes on nuclear technology which the United States Government presented at the Second International Conference on the Peaceful Uses of Atomic Energy at Geneva last year.

Nuclear Power . . . confidence grows in the rapid attainment of economic production

END OF THE YEAR 1958 found the world with approximately 6,000,000 kw (electrical) of nuclear power capacity either under construction or in the design stage. Actually, two-thirds of this capacity was under construction.

Compared to the total 135,000,000 kw of electrical generating capacity installed in the central stations of the United States alone, the 6,000,000 kw of nuclear capacity may not seem impressive. Yet when viewed in the light of the fact that the nuclear power industry is still only about five years old, the figure takes on added significance. It was in May, 1953 that the U. S. Atomic Energy Commission released its first unclassified report on the feasibility of nuclear power reactors. At that time no actual nuclear power plants had been started anywhere in the world, except perhaps the 5000-kw Russian nuclear reactor which began operation in May, 1954.

The 6,000,000 kw of nuclear power capacity involves 59 separate reactors in 12 different countries. The bulk of this capacity is being installed in three major countries: Great Britain, the United States, and Russia, with Great Britain leading with a total of 2710 Mw. The United States is second, with a total of 1025 Mw, and the USSR has nuclear plants under construction involving a total of 770 Mw. By far the largest units are being constructed in England, where at least three stations of 500 Mw capacity are being built. Indeed, the Central Electricity Authority recently announced plans to construct the largest nuclear power station in the world, with a capacity of 650 Mw, on the Suffolk coast in England.

The tremendous world-wide development of nuclear power technology and the rate of progress during the last five years provides a measure of what may be expected in the years ahead. The United States alone has in operation or under construction a total of 750,000 kw of electrical nuclear capacity.

Reason for England's spectacular progress in nuclear power is due to the critical fossil fuel situation there. Rising fuel costs in England as well as in other European countries where fuel is scarce compel the development of nuclear power stations. And it is because of the urgency of the situation that England, at least in the first phase of nuclear power development, has centered on the use of one particular type of reactor, the gas-cooled, graphite-moderated reactor because this type of reactor is simple in principle and was known to be feasible at the beginning of the program. The initial success of this type of reactor has led British designers to extend its use further into the future, with modifications adapting it to much higher temperatures and, therefore, improving the economy.

The western European nations also have launched an ambitious nuclear power program under the European Atomic Energy Community (EURATOM). This program involves the construction by 1967 in the six EURATOM countries — Belgium, France, Germany, Italy, The Netherlands, and Luxembourg — of 15,000,000 kw of nuclear power capacity. An important event of the year was the final signing of the agreement by all of the six nations involved. Of great importance to U. S. manufacturing firms is the international agreement, signed on November 8, 1958, between the U. S. and EURATOM for a 1,000,000-kw joint program of nuclear power development. This program involves the construction by 1963 in the six EURATOM nations of six large-scale nuclear power plants based on U. S.-type reactors. This would provide sufficient electrical generating capacity to meet the power requirements of more than 5,000,000 people in the EURATOM area.

Conditions for nuclear power development in the United States are quite different from those in Europe since fossil fuels are still abundant and relatively cheap. It is, therefore, more difficult for nuclear power to compete with fossil fuels at the present time. Consequently, the trend in the U. S. has been to develop many different reactor concepts for possible future adoption. Thus the U. S. has the largest and most varied experience with reactors, and has a total of 11 reactors which have produced electricity. These are listed in Table I. With the exception of Shippingport Station, which completed its first year of operation in December, 1958, all of these reactors are relatively small, and are primarily experimental units built under the Atomic Energy Commission's Power Reactor Development Program. Shippingport, also, was built under this program and while it is an experimental plant, it is a large-scale central station plant actually supplying electricity to a commercial utility system, that of the Duquesne Light Co. in Pittsburgh.

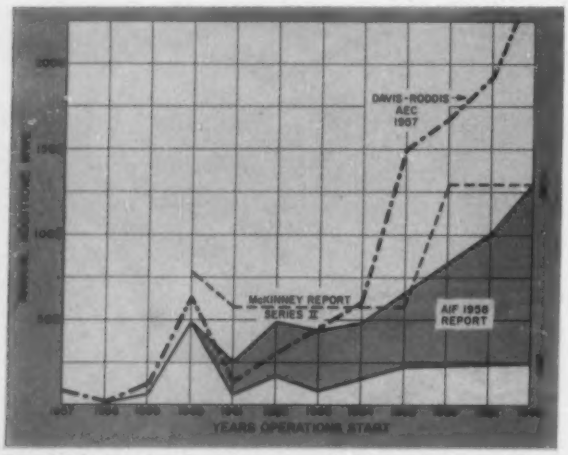


Fig. 1. Estimates of various organizations of the probable amount of new nuclear power added annually by 1968

Much of the early work on atomic power in the U. S. was for naval propulsion where costs are not of primary concern. To a large extent, the Shippingport system is based upon the design used in the Nautilus, and its costs are correspondingly very high. Shippingport, therefore, must not be used as a criterion in evaluating future nuclear power plant costs. The over-all cost of Shippingport is around $1200 per kw. By comparison, the estimated cost of the 134,000-kw pressurized water nuclear plant for the Yankee Electric Co, under construction at Rowe, Mass., is $360 per kw. Difference between the capital costs of the first two pressurized water plants is indicative of the trend toward further reduction of nuclear plant costs.

TABLE I. POWER REACTORS WHICH HAVE PRODUCED ELECTRICITY

Name	Location	Type	Electric Power (kw)
1. Experimental Breeder Reactor No. 1 (EBR-1)	NRTS,* Idaho	Fast Breeder	200
2. Homogeneous Reactor Experiment No. 1 (HRE-1)	Oak Ridge, Tennessee	Aqueous Homogeneous	140
3. Boiling Reactor Experiment No. 3 (BORAX-3)	NRTS, Idaho	Boiling Water	1700
4. Boiling Reactor Experiment No. 4 (BORAX-4)	NRTS, Idaho	Boiling Water	2400
5. Experimental Boiling Water Reactor (EBWR)	Argonne Nat. Lab. Lemont, Ill	Boiling Water	5000
6. Sodium Reactor Experiment (SRE)	Santa Susana, California	Sodium Graphite	6000
7. Vallecitos Boiling Water Reactor	Pleasanton, California	Boiling Water	5000
8. Shippingport Atomic Power Station (PWR)	Shippingport, Pennsylvania	Pressurized Water	60,000
9. Homogeneous Reactor Experiment No. 2 (HRE-2)	Oak Ridge, Tennessee	Aqueous Homogeneous	300
10. Army Package Power Reactor No. 1 (APPR-1)	Ft. Belvoir, Virginia	Pressurized Water	2000
11. Argonne Low Power Reactor (ALPR)	NRTS, Idaho	Boiling Water	200

* National Reactor Testing Station

A similar situation exists with respect to nuclear fuel costs. The fuel cost for Shippingport Station is figured at 43 mills per kwh. Compared to this fantastically high figure, the recent Fuel Cost Analysis of the Edison Electric Institute gives a total fuel cost for a 1.8 per cent enrichment of uranium dioxide of 4.1 mills per kwh, while for the case of natural uranium, the total fuel cost is 3.7 mills per kwh.

For significant cost reduction in the immediate future, however, we must look to the boiling water type of reactor, exemplified by the 180,000-kw Dresden Nuclear Station of the Commonwealth Edison Co, now nearing completion near Chicago. According to company estimates, this nuclear power plant will be built for a total cost of $250 per kw, and on the basis of its cost of around $36,000,000 which Commonwealth Edison will capitalize, it is predicted that the total power cost, including fixed charges, operating expense, and fuel, will ultimately approximate ¾ cents per kwh. This is about the same as the cost of power produced by the company's coal-fired plants.

The total plant cost is $45,000,000 but $15,000,000 of this is research and development cost which would not be involved in a duplicate station of the same design. This $15,000,000 research and development cost is borne by 15 other electric utility companies associated with Commonwealth Edison Co in this project. However, one factor in the low construction costs of the Dresden Station, no doubt, is the General Electric Company's research and development contribution in the form of a favorable contract price. General Electric Co is designing and constructing this station.

While other types of reactors may prove economically favorable, at present the boiling water reactor seems to offer the best chance of competitive nuclear power in the near future. In the case of the Dresden Station, exhaustive studies indicate that its initial capacity of 180,000 kw can be raised to 300,000 kw with an advanced core design but using the same pressure vessel. This would further reduce the cost per kw.

An important event in boiling reactor technology last year took place at the Experimental Boiling Water Reactor (EBWR) of the Argonne National Laboratory. This plant, which supplies 5000 kw, electrical, to the Laboratory, was originally designed for a power level of 20 megawatts, thermal. On April 25, 1958, the Argonne engineers deliberately ran the power level up to over 62 megawatts. Thus, without making any changes in the reactor design, this unit was operated at more than three times its design output. This automatically reduces EBWR's power cost by an impressive 40 per cent.

A Look at Nuclear Fuel

At present, fuel preparation and fabrication cost is a major item in nuclear fuel cost, but it is expected that this can be substantially reduced in the future. This reduction will result from increased burnups, cheaper fabrication, and reduction in fuel preparation and fabrication costs by increased production.

There has recently been a general switch from the use of uranium metal to the use of uranium oxide as reactor fuel. This may have been initiated to avoid the dangers involved in uranium-water reactions but it has other benefits as well. The oxide has proved much more resistant to radiation and does not suffer from the thermal growth problems of the uranium metal fuel elements. Much larger burnups, therefore, appear possible. While oxides now cost more to fabricate than metal, these costs are expected to decrease as fabrication facilities become available and larger orders materialize. Further cost reductions may result from newly developed methods of coextrusion and swaging which are used in the fabrication of oxide elements. These methods are expected to prove more economical than the present procedure of fabricating and grinding oxide pellets.

Power Reactor Development in the U. S.

Most of the nuclear power projects in the United States presently under construction or planned are being carried out under the AEC's Power Reactor Demonstration Program, which is now in its third round. This program reached a new level of maturity during the year with seven power experiments in operation and Shippingport Station delivering its full 60,000 kw to the Duquesne Light system. Major construction was started on the Experimental Breeder Reactor No. 2, the last of the experimental reactors in the 5-year program approved by the Congress in 1954.

From a long range standpoint, the most interesting project under the Demonstration Program is that of the Power Reactor Development Co at Monroe, Mich. There, a group of utility companies headed by Detroit Edison are building the Enrico Fermi *Fast* Breeder Reactor. This project, involving a total cost of $71,000,000 is the first attempt in the U. S. to construct a fast breeder for commercial use. It will have a capacity of 100,000 kw, electrical, and plans call for initial operation in 1960.

This project is of great importance because, from a theoretical standpoint, the fast breeder is among the most interesting and potentially valuable of all reactors since it promises to make use of all the natural uranium available to us rather than only that fraction represented by the Uranium-235 content.

Another large project under the AEC's Reactor Demonstration Program is that of the Yankee Electric Co, the 134,000-kw pressurized water plant under construction at Rowe, Mass. This plant is being designed by Westinghouse and the reactor constitutes an improvement over the Shippingport reactor. In the case of Shippingport, extreme care was taken to avoid any possibility of boiling in the primary cooling system. The Yankee reactor is being designed so that a certain amount of boiling will take place in the reactor core, thereby increasing the effectiveness of heat transmission. Besides these two projects, the Reactor Demonstration Program involves 10 other plants varying in size from 10,000 kw to 200,000 kw, and a number of new reactor concepts.

In addition to the power reactors being built or planned under the AEC's Reactor Demonstration Program, a considerable amount of nuclear power development is being undertaken independently by electric utility companies. Four major projects are under way, all financed by private capital. First is the Indian Point Station of Consolidated Edison Co of New York. This is a large plant with a total rating of 275,000 kw, but since 112,000 kw of this total will be supplied by an oil-fired superheater, its nuclear rating is only 163,000 kw. It is estimated that when completed in 1960 that Indian Point will produce power at 13 mills per kwh.

Fig. 2. Model of the C Stellarator being built at Princeton in the thermonuclear program. Photo, Allis-Chalmers.

Second is the Dresden Station of Commonwealth Edison being built near Chicago. This 180,000-kw all-nuclear plant will have the first dual-cycle boiling water reactor and is the largest nuclear plant under construction in the U. S. During the fall of 1958, this project was three months ahead of schedule.

The third project is that of the General Electric and Pacific Gas and Electric Co at Vallecitos, California. This is a 5000-kw, electrical, boiling water power plant supplying electricity to the Pacific Gas and Electric Co system. Vallecitos, however, is an experimental plant built largely to test components for the full-scale Dresden Station of Commonwealth Edison Co.

The fourth project also involves General Electric and Pacific Gas and Electric Co. On February 18, 1958, the Pacific Gas and Electric Co announced that it had completed negotiations to build a 60,000-kw advanced boiling water nuclear plant at its Humboldt Bay Station south of Eureka, California. This project is unique in that this nuclear unit will form the third generating unit in a conventional steam-electric Station. Scheduled for completion by 1962, this unit, situated in a moderately high-cost fuel area, is expected to achieve competitive power at 8 mills per kwh with its second core.

Perhaps the best measure of industrial participation in the nuclear energy program is in the growth and importance of the Atomic Industrial Forum. This is a nonprofit industrial management organization to foster the development and use of atomic energy for peaceful purposes. Organized in 1953, the Forum today has over 500 organizations and 1700 individuals on its membership rolls in the U. S. and 24 other nations. At least 90 per cent of the non-government organizations in the U. S. which are now deeply engaged in atomic energy activity are members of the Forum. Its members include equipment manufacturers, utilities, chemical organizations, engineering and consulting firms, universities, research laboratories and labor organizations.

Future Nuclear Power Development

Of considerable interest with respect to future nuclear power development were two reports issued during 1958, the first that of the Technical Appraisal Task Force on Nuclear Power to the Board of Directors of the Edison Electric Institute, and the second, the report of the survey made by the Industrial Atomic Forum. While these reports vary in detail, there is considerable agreement between them as to the future of nuclear power development. Fig. 1 is a chart which illustrates various predictions that have been made concerning the number of

nuclear megawatts expected to be installed in large-scale nuclear plants annually in the U. S. until 1968.

The new Atomic Industrial Forum survey estimates that from 250,000 to 1,300,000 kw (e) of nuclear capacity will be added annually in the U. S. by 1968. The report also shows that the nuclear industry is now building toward the installation of more than 500,000 kw by 1960. Most significant, however, is the prediction that if the present level of Government and industry investment in uneconomic nuclear facilities is continued, an *economically competitive plant may be achieved by 1964*. The resultant growth, under optimistic assumptions, produce a total United States reactor capacity by 1968 of about 6,000,000 electrical kilowatts.

Up to the present the cost of nuclear power plant components — pumps, valves, fittings, piping, etc — has been higher than costs of similar equipment for conventional plants. The trend is downward, and this will reduce the per-kw costs of nuclear power plants after 1960. It is estimated that the annual dollar volume of sales for United States large nuclear reactor systems, exclusive of turbine-generator equipment, will increase from approximately $300,000,000 in 1960 to a probable range of $350,000,000 to $600,000,000 in 1968.

The Geneva Conference

From a nuclear standpoint, the most important event of the year 1958 was the Second International Conference on the Peaceful Uses of Atomic Energy held at Geneva in September. Attended by over 5000 delegates from 69 different countries this conference reflected the growing force of nuclear power development in the industrialized nations of the world. Of tremendous interest was the spectacular thermonuclear exhibits of the United States government. These far exceeded those of other countries both in magnitude and variety of systems shown, and to a large extent recouped the loss of scientific prestige the U. S. had suffered by the launching of Russia's satellites.

Despite the spectacular quality of the thermonuclear exhibits and their impact on the visitors, perhaps the most significant result of the conference was the confidence it reflected in the future of nuclear power. At the previous conference, in 1955, there was great interest in reactor development but it was of a speculative rather than a practical nature. At this last meeting the attitude was quite different; there was little doubt in the minds of any that nuclear power was not well on the way and that economic nuclear power was only a few years off in many countries including the United States.

While the glamor of thermonuclear research stole the show at Geneva there was a more realistic attitude toward nuclear development as a whole, and despite the tremendous interest in the ultimate possibilities of thermonuclear power, everybody seemed to realize that the real task for the immediate future was in the development of economic *fission* reactor systems.

JOHN C. GIBB, Senior Engineering Representative, Socony Mobil Oil Company, Inc

Born and educated in Ithaca, N. Y., Mr. Gibb graduated from Cornell University in Mechanical Engineering. Following graduate work and varied diesel engine field experience, he joined Socony Mobil in 1945, and is responsible for lubrication in marine, railroad and industrial diesels. A fluent writer, he is a Registered Professional Engineer in N. Y. and active in ASME and SAE.

Diesel Engines... many improvements, more to come

THE DIESEL ENGINE has been long established in a number of areas of power application in the US where its reliability and particularly its economy (as compared with other possibilities) make it the most useful and profitable prime mover. Up to units of perhaps 20,000 hp, no other thermal machine for producing power is yet able to exceed or even equal the ability of even a small diesel engine to turn a minimum amount of liquid or gas hydro-carbon fuel into a horsepower-hour.

In the stationary diesel power plant field, the three most obvious trends have been towards the introduction of new designs of higher rotative speed, increased bmep, and greater power per engine. A rather considerable number of engines have been placed in stationary power plants using modified types otherwise used and originally designed for automotive, marine, or locomotive service.

There are, however, a large number of modern diesels developed primarily for stationary power plant service and corresponding marine applications, usually of intermediate rotating speed in the 400 to perhaps 700 rpm range. The four-cycle engines are invariably turbo-supercharged and two-cycle engines with turbo-superchargers have recently appeared on the market.

As speed and specific power output go upward, there is a strong trend towards the use of 12 or 16 cylinders in V arrangement even for units of 3000 to 5000 hp or so. It is notable that typical horsepower of diesel engines has increased greatly in recent years. Many municipal plants established perhaps thirty years ago with two 300 hp units are now installing additional engines rated at 3000 hp each, or thereabouts.

Where units of 2000 hp to 8000 or 9000 hp are needed, the large bore two cycle engine continues to be popular especially where the use of low grade or residual fuels is desirable. Here also rotative speeds have increased somewhat and the use of turbo-superchargers for two stroke cycle engines is appearing.

In the central and southwestern portions of the US, the wide availability of natural gas at reasonable prices has resulted in the almost universal use of dual-fuel diesel engines wherein 90 to 95 per cent of the heat units are supplied by natural gas, the rest is pilot fuel oil. A fairly recent development here has been the tri-fuel engine and the high compression spark-ignited gas engine.

Use of low-cost residual fuels, sometimes known as Bunker C fuels or boiler fuel, in diesel engines has been of economic interest only in a relatively few areas, as in Florida. Diligent trial of many combinations of equipment have resulted in techniques for the cleaning and heating of residual fuels making them usable in many diesel power plants, principally where relatively large units operate at moderate speeds at good loads.

Recent development of special lubricating oils to prevent the excessive cylinder wear often associated with the use of high-sulphur residual fuel will help greatly in keeping down the costs of diesel operation.

From a mechanical standpoint, it is obvious that the builders of diesel engines are continuing to develop and improve their designs in terms of efficient output rating and in service reliability. The ultimate possibilities are not yet in sight to the writer. It appears that the most immediate improvement should be in the fuel combustion and the ability to satisfactorily use fuel oils of poor quality under adverse operating conditions.

SABIN CROCKER

A consulting engineer in New York, Mr. Crocker is a Fellow in ASME and the author of Piping Handbook. For many years he was vice-chairman of ASA Sectional Committee on Code for Pressure Piping. He retired last May after 10 years with Ebasco Services Incorporated where he was a Principal Engineer in the Consulting Engineering Department. Prior to that, he was with Detroit Edison Co for some thirty years in different engineering posts. He was graduated from the Engineering College of the University of Michigan.

Developments in Power Piping

ROUNDUP OF recent developments in the power-piping field should not be confined to the last few months alone. Really significant developments in materials or methods usually require a considerable period of incubation by their sponsors under close observation before reaching a stage of proven dependability with industry-wide acceptance and code recognition. Some initially promising ideas never do "hatch" for one reason or another and drop out of the picture. For an idea to prove out it must have considerable economic merit, superior safety features, or serve as a substitute for some item in short supply.

Where new methods are involved, their widespread adoption is sometimes limited to shops or fabricators which can carry on the work with special equipment under carefully controlled conditions. In other words, not all promising new developments are universally applicable, especially in their early stages. For these reasons, it often takes several years for a new concept to progress to the stage where it has secured sufficient acceptance in the power-piping field to be considered a really significant development. This preface will serve to explain the need for discussing trends as well as wholly new ideas.

Until quite recently the use of carbon and low-alloy ferritic steels has predominated in power piping. For steam temperatures above 1100 F, however, and for nuclear piping, there is a need for stainless steels of the austenitic type. These steels introduce new problems in fabrication and welding as well as in pipe manufacture. Although nuclear work has been underway for 15 years or more, its early stages were clouded in secrecy and only recently have several interesting developments come out from under security wraps. Brief mention of some of these items is pertinent here although space does not permit full explanation.

Growing Use of Austenitics

Experience has shown that the need for new materials having superior properties for special applications usually requires solving different metallurgical problems peculiar to their fabrication and use. Several such problems are currently in the active stage.

Pioneer efforts with austenitic stainless-steel piping extending over some 30 years have been fraught with difficulties. Although such materials have much to offer in the way of corrosion resistance at all temperatures and strength at high temperatures, there are offsetting disadvantages among which are: (1) high cost of materials; (2) difficulty in fabricating and welding; and (3) certain deficiencies in metallurgical stability where temperature is experienced in fabricating, welding, or service.

One vexing problem with austenitic steels is the tendency with exposure at temperatures of 800 to 1600 F for chromium carbide to come out of solution and deposit at the austenite grain boundaries, thus producing intergranular weakness. This tendency can be minimized through adding to the steel small amounts (one percent or less) of stabilizers such as columbium, titanium or tantalum which tend to hold the carbides in solution. However the introduction of stabilizers tends, in turn, to aggravate the tendency for crack formation in welds. This tendency to cracking has to be compensated for by using a welding rod that deposits some ferrite along with the austenite, thus introducing more problems. These experiences have shown the desirability of trying to obtain stability through other means such as alloying with 2 to 3 per cent of molybdenum, or holding the carbon content well below the 0.08 per cent maximum usually allowed for stainless steels. The use of Type 316 austenitic steel (containing 2 to 3 per cent molybdenum) for 1100 F steam piping instead of the columbium stabilized Type 347 is an example of one method. The other is illustrated in the use of the low-carbon grade of Type 304 (straight 18 per cent chromium 8 per cent nickel) for its corrosion resisting properties in nuclear piping where the temperature is not too high for an unstabilized steel.

Plated and Clad Steels

For some applications in nuclear or process piping, corrosion resistance can be obtained most economically through the use of plated or clad steel where the stress load is carried by the base metal. This is not a new idea inasmuch as galvanizing and other coatings have been used for years in certain applications. The novelty in this case arises from the importance of the services so treated. Obviously operating temperature cannot exceed safe limits for the load carrying ability of the base metal.

Welding-end Fittings

For large-diameter heavy-wall power piping in high-pressure and/or high-temperature service there often are cases where cast or forged-and-bored welding-end fittings can be used to better advantage than pipe bends or the type of fitting formed from pipe or plate. Considerable interest has developed lately in such fittings for reasons stated below.

Elbows of the cast or forged-and-bored varieties have an advantage over pipe bends in that they are not subject to thinning of the wall in the process of manufacture as is the case in bending pipe. Where pipe walls are specified to close tolerances, it is advantageous to avoid the neces-

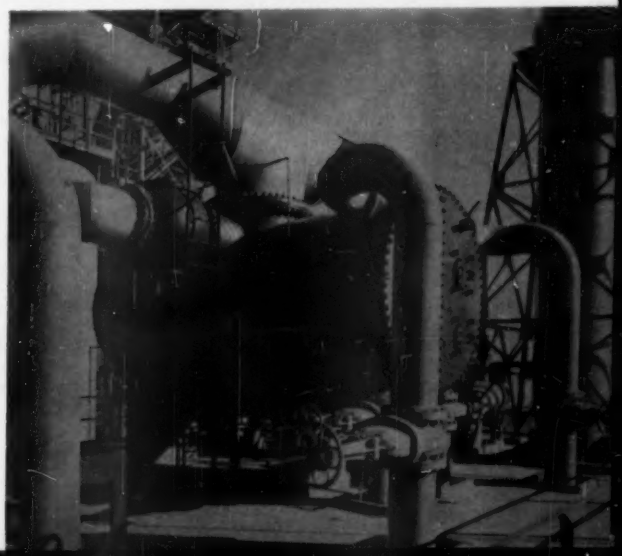


Fig. 1. Improved techniques developed within past decade have resulted in greater use of welding in today's plants

Fig. 2. Installation typical of modern high-pressure piping design. Note method used to support the heavier runs

sity of ordering overthickness pipe in order to compensate for thinning of the pipe wall during bending. Another advantage of cast or forged elbows, as compared with fabricated elbows or pipe bends made of welded-seam pipe, is the absence of welded seams in curved sections subject to flexure in service due to thermal expansion.

Tees and wyes of the cast or forged-and-bored varieties often seem more substantial than their counterparts as fabricated by welding from pipe or plate. This is particularly true in the case of wyes which are desirable from a flow standpoint but are difficult to reinforce properly if of the fabricated variety.

Growing interest in both cast and forged-and-bored fittings is attested by the number of reliable manufacturers now offering these products. In the absence, as yet, of suitable national specifications for these products, several engineering firms have formulated their own specifications in cooperation with fitting manufacturers. Among the items covered in such specifications are: (1) clarification of rules for determining wall thickness in irregular-shaped sections; (2) method of heat treatment; (3) requirements for hydrostatic testing; (4) methods of nondestructive testing to determine soundness of metal, with standards for acceptance or rejection; (5) degree of finish and dimensional tolerances; and (6) repair of injurious defects.

Miscellaneous New Materials

Miscellaneous new piping materials finding some use, or being considered for use, in power piping are: (1) plastics of various sorts; (2) a modernized and improved kind of wrought iron introduced during the past year; (3) nodular cast iron suitable for flanged or screwed valve bodies and similar items; and (4) super-strength alloys proposed for extreme high-temperature service beyond present commercial limits.

Hydrogen concentrations above a few parts per million are considered objectionable in large castings or forgings intended for severe service conditions because of the possibility of hydrogen embrittlement. Vacuum-pouring of ingots or castings is being employed in some cases to eliminate gases and volatile matter and, in particular, to minimize the amount of hydrogen left in the steel. This possibility offers promise of obtaining superior steels for severe piping service as well as for turbine-rotor forgings and the like.

Plastic piping, so far at least, has not found the use in power piping that it has in chemical process piping and similar fields. Its use around power stations is mostly confined to; (1) chemical feed i water-treatment systems; (2) well-water piping where mildly corrosive conditions exist; and (3) buried lawn-sprinkler piping. Undoubtedly it merits more extensive acceptance, but this hangs on greater interest being developed in the product including appropriate recognition by national safety codes and specification writing bodies.

Headaches of Procurement

Trend of power-plant development to larger units for higher pressures and temperatures, and frequently with crossover piping incidental to the reheat cycle, has added to the complexity of piping procurement problems. Usually the strictly power-cycle piping is of diameters, wall thicknesses and materials distinctly different from those suiting other industries. Furthermore, quantities required for any given project or, in fact, the power industry as a whole within any reasonable period, are too small to be commercially attractive for production methods suited to turning out light to medium wall cross-country gas and oil piping in 100-mile lots. Under these circumstances, American pipe mills producing seamless pipe by piercing and rolling on a Mannesman type mill have indicated that they cannot afford to tie up existing equipment or add costly new equipment to permit filling small orders of unusual size pipe. Mannesman mills, with their complicated equipment and high-speed production methods, are not suited to this sort of work.

Nuclear power piping brings the need for other new kinds of pipe suitable for resisting corrosion and/or the effect of radioactivity. Much of this pipe is stainless austenitic steel. Due to the different pressure and temperature conditions obtaining, wall thicknesses as well as materials are apt to differ considerably from conventional steam-cycle plants.

This situation has led to the development of other methods of pipe manufacture better suited to catering to the power industry's needs. Some new methods produce pipe which is equivalent to or resembles conventional pierced-and-rolled seamless, whereas other methods use plate with a longitudinal welded seam. Plated or lined pipe are further possibilities in nuclear piping.

Seamless or Equivalent Pipe

Among methods of producing pipe resembling conventional seamless are cupping and drawing, extruding, hollow forging on a draw bench, rotary forging, centrifugally casting, and forging and boring. Each of these methods involves a metal flow or pattern quite different from that obtained from the spiral spinning action used in piercing and rolling pipe from a solid billet on a Mannesman mill. There may be differences between methods in the homogeneity of metal structure or the extent of hidden defects that will have to be determined from experience with the several products. Likewise, quality of surface finish inside and out is another item for consideration which differs between methods and the kind of material being processed.

Where a method involves machining inside and out, two desirable results are accomplished: (1) surface defects are removed and a specified degree of finish obtained; and (2) wall thickness tolerances can be reduced below the 12½ per cent plus or minus which is characteristic of conventional seamless pipe. In ordering pipe, advantage can be taken of the result expected for that type by specifying wall thickness to suit its closer tolerance.

Centrifugally-cast austenitic steel pipe, including the hydroformed variety, is finding considerable acceptance in the nuclear field where it seems to be attractive, price wise, for the specified service conditions. Specifications with maximum-allowable stress values for both ferritic and austenitic-steel centrifugally-cast pipe were issued in 1958 as Case No. 32 under the Petroleum Refinery Section of the ASA B31 Code for Pressure Piping. Similar action is under consideration in the Power Section of the B31 Code but up to the time of writing this article, no case had been published for that section.

Welded-Seam Pipe

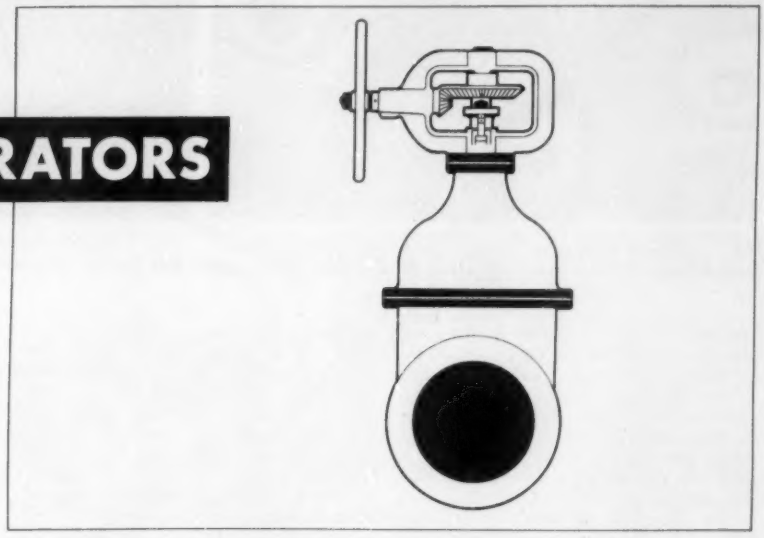
Welded-seam pipe made from ferritic-steel plate with a 100 per cent radiographic examination of the seam is proving useful in hot and cold reheat piping for large central-station units. Diameters and wall thicknesses of such pipe often are beyond the scope of presently available Mannesman seamless mills, whereas the other varieties equivalent to seamless may not be able to qualify from a cost or delivery standpoint. Under these circumstances, a real need exists for high-quality welded-seam pipe. Such pipe usually is ordered to Class 1 of ASTM Specification A155 of some specified plate composition.

Austenitic stainless-steel pipe having a welded seam is specified for some nuclear projects where it appears attractive price-wise. Use of stainless-clad pipe with welded-seam carbon-steel base metal also is under consideration for nuclear work. *continued on page 103*

Power Engineers' Valve Manual . . . .

This continuation of the Valve series gives details of operating mechanisms used with high-pressure valves. The author is an expert in this field, and has spent many years in research on valves. The article discusses the need for operators, and the various types in use today

VALVE OPERATORS



By LAURANCE CARR
Director of Research
and Engineering
Edward Valves, Inc
Subsidiary of Rockwell Mfg Co

Mr. Carr graduated from the University of Chicago with both Bachelor and Master of Science degrees. He joined Edward Valves in 1936, in the position of metallurgist.

Later, he was made Chief Metallurgist, then Director of Research. This was followed by advancement to his present position.

Among his many technical and professional affiliations, Mr. Carr belongs to American Society of Mechanical Engineers, American Welding Society, and American Society for Metals. He has written many papers for professional journals and for such meetings as the American Power Conference.

ONE IMPORTANT DECISION in designing of modern high-pressure power plants is the type of operators to be used on the large, high-pressure valves involved. Let's define "large" high-pressure valves as any over 10-in. at 600 psi, 8-in. at 1500 psi, or 6-in. at 2500 psi. In many cases the valve operator, plus its power and indicating connections, may cost more than the basic valve itself. Consequently, it is well worth the time to study actual requirements and to consider the many types of valve operators available.

The basic requirement is tied up in the operating characteristics of gate and globe valves. Almost without exception, such large valves are operated by a valve stem extending through a packing chamber to the closure member. The valve stem may travel a distance equal to the diameter of the pipe down to a distance 25 percent the diameter of the pipe. Thus, closing such a valve is equivalent to moving a piston, whose diameter is equal to the valve stem diameter, through a high-pressure chamber for a distance equal to total valve travel. In some modern piping systems, this can result in a considerable force requirement.

At the end of this travel, the closing force must be increased enough to create a tight seal on the valve seat. In typical large, high-pressure power plant valves, these closing forces may be as high as 25,000 lbs exerted through a distance of 10 in. just to push the stem into the valve, plus 250,000 lbs exerted through a distance of 1/10 in. to create a tight seal. Forces of this order acting through such distances represent a large amount of work.

About 1 hp would be required to close such a valve in one minute, if we had a perfectly efficient operating device. But, the devices that can generate such large forces are relatively inefficient, so the actual power requirements of operators for large valves are much greater than 1 hp.

Forces Undergo Transition

Because the greatest force is required for only a short distance near the point of seating, and because a lesser force is required for the longer distance between open and close, valve designers have sought many forms of valve operators to take advantage of the two force conditions. For example, typical gate valves almost always call for total stem travel equal to something a little more than the inside diameter of the pipeline.

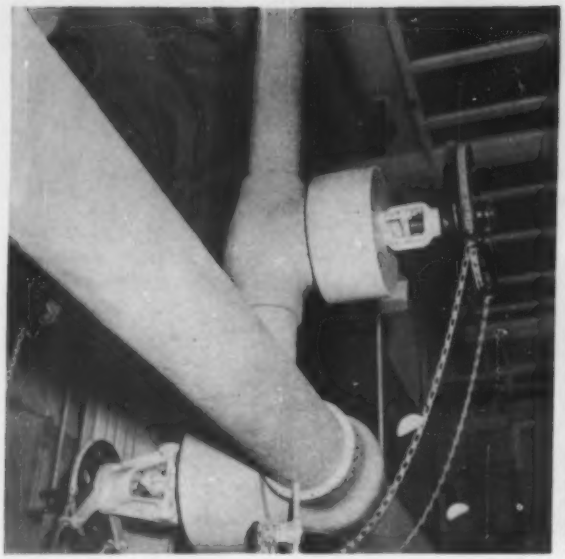


Fig. 1. Chainwheels give freedom in valve location. Clearance is required, but chain is tied out of way when not in use

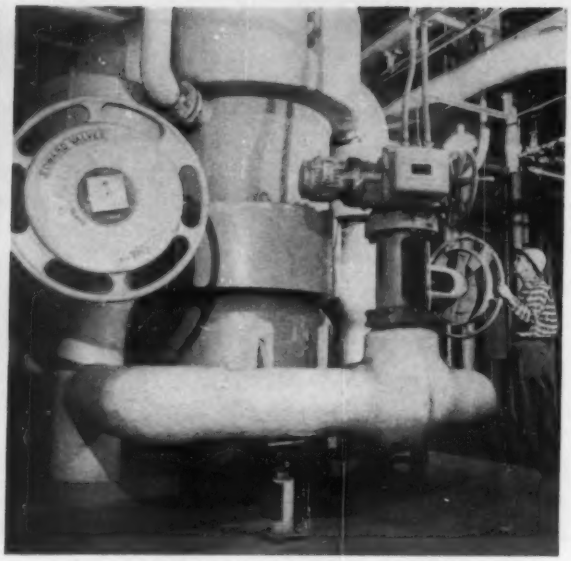


Fig. 2. Hand-operated valve (left) is for infrequent operation. Motor-operated valve permits instant bypass of heater

During this period of travel, whether opening or closing the valve, the total force on the stem is equal to pressure (inside the valve) times area of stem.

Now, the typical stem might have a cross section area of 7 sq in. and might be acted upon by a pressure of 2500 psi. An outward thrust of 18,500 lbs would act on the stem at all times. To this we add the friction load for the valve packing . . . which frequently is figured as 10 percent of the stem load. So, we add another 2000 lbs to the 18,500 lbs above.

Actual seating of a wedge gate in its seat might seem rather difficult to calculate, at first glance. On the other hand, pulling the wedge off of its seat is perhaps a clearer thing to visualize. Under extreme conditions, the valve gate rests against the downstream seat face with a maximum of full line pressure on the upstream side and zero pressure on the downstream side. So, one of the forces holding the wedge against the seat is line pressure times seat area. The force to slide the gate off the seat is then line pressure times seat area times coefficient of friction of the sliding surfaces. A reasonably conservative figure for the friction coefficient on the internal metallic surfaces of a large, high-pressure valve might be 0.33. Operating force for pulling the valve open, on the basis of this calculation, then would be one third the line pressure differential across the wedge times the seat area.

If the gate were wedged between two seats, considerably higher force might be required to pull it free. Wedging action could be generated by initial closing, and/or by thermal expansion or contraction that took place after the valve had been closed. The two seats could have contracted against the faces of the gate wedge. The valve stem might have contracted less than the bonnet and yoke assembly. Hence cooling of the valve might have forced the gate into tighter engagement between the two seats. Forces of this nature are very difficult to calculate. Valve designers generally rely on operating experience to judge the magnitude of such forces. But they can be expressed generally as some fraction of operating differential pressure times valve seat area.

In securing tight closing of a wedge gate valve, total closing force requirement is often figured on the basis of differential pressure times seat area times friction coefficient, plus a 10 per cent additional load to provide a moderate amount of wedging between the two seat faces, to develop the maximum seat tightness.

Application of these formulae generally results in a force for seating and unseating gate valves that acts through a distance of about ¼ to ½ in. This is roughly seven times the force for operating from closed to wide open. The transition from high force to lower force takes place rather abruptly near the fully closed position because line fluid forces have relatively little effect on the valve gate once it is slightly open.

Globes Require Higher Force

Globe valve operating requirements are much like gate valve requirements. Globe valves, however, have shorter total lift and require a greater seating force. Ordinary globe valves may lift only 25 per cent of the valve pipeline diameter, although specially designed low-pressure-drop valves may have stem travel as high as 75 or even 100 per cent of line diameter. Globe valves seat by setting the disc directly into the seat port, in opposition to the line pressure. Hence, the seating force required is pressure differential across the valve times full area of the seat port, without application of the friction coefficient noted for the gate valve. An allowance of 10 percent is added for tightness.

If the higher pressure is under the valve disc, the closing force is required as a compressive load in the valve stem to resist the pressure on the disc; this force is a tensile load on the valve stem, to lift the disc off the seat, when opening the valve.

As in the case of the gate valve, seat forces in a globe valve dissipate rather quickly upon opening. So the high force requirement lasts only through limited distance, say ¼ or ½ in. Regular stem force is needed for 90 percent or more of the total stem travel. In a typical case, the globe valve seating force is 10 times the force required for moving from open to close.

Differential Is a Variable

Quite a distinction must be made between valve opening and closing forces, and valve seating forces. Because they differ by as much as 10 to 1, the distinction between these forces is important. In actual practice, however, the seating load itself often varies widely. In simple terms, the seat load required to close a valve is the full pressure differential as applied across the seat area. A conservative assumption is that the full internal pressure of the line is applied to one side of the seat and atmospheric pressure to the other. In certain valve operations, though, this is almost never the case. Many recirculating lines develop high pressure in the line, but the differential pressure across the circulating pump is

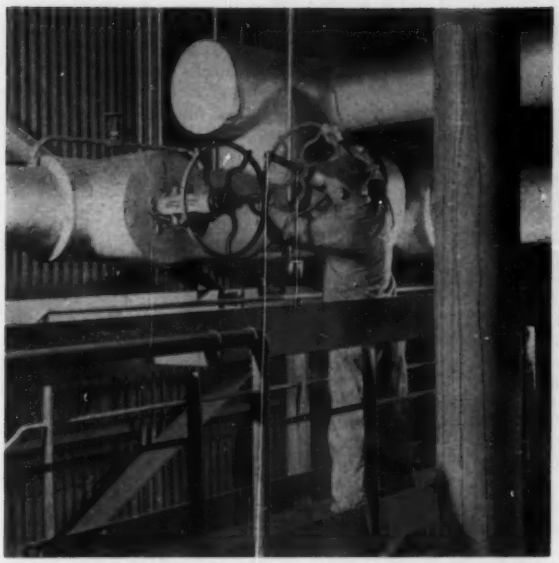


Fig. 3. Handwheels must be accessible, and in such positions that operators can exert necessary force to operate valves

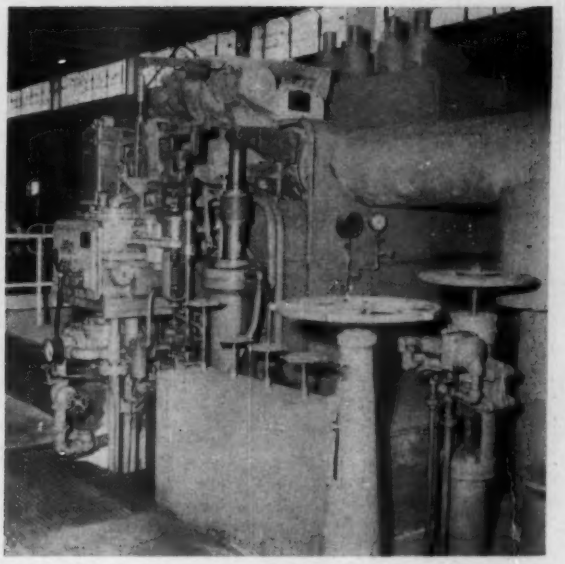


Fig. 4. Pedestals give extensions to valve stems, and permit operating handle to be in convenient and protected position

low. The valve might close off the low-pressure across the circulating pump, and not close or open against the full line pressure, measured with respect to atmospheric pressure.

Less than full line pressure develops, also, where large valves are equipped with bypass lines. In many cases, the large valve is not operated until the bypass line has been opened, to hold down the differential across the large valve.

Boiler installations, in particular, may present pressures across a valve higher than the full design pressure. Boiler and piping code practices call for testing lines at 1½ times working pressure. A valve may be used to isolate a section of the boiler or line for developing this test pressure. The valve closing mechanism must be 50 per cent stronger than might be expected under normal conditions.

Check Valves Need Less Force

Of particular interest in many power plant operations is the case of the stop-check valve. A free-floating disc in the valve has a valve stem for securing the disc to the seat. If the ordinary high-pressure differentials (created during closing) come from under the valve disc, the valve stem must transmit the same forces as for a globe valve. In many applications, though, the differential tends to be on top of the valve disc. The valve stem is used really as a securing device to hold the disc in place to avoid any accidential opening. Maximum seating load on the valve stem might be only three times the load required for pushing the stem from open to close. The valve operator requirement is somewhat different than for the standard globe or gate valve.

Practically all the valves under discussion are operated by a stem thread acting through a bronze nut. A few valves of very special design and application occasionally are operated by direct-acting hydraulic cylinders. The cylinder idea is always intriguing because of the low friction loss in such devices and the ability to multiply force greatly. But operating pressure must be continually maintained to hold the valve in any one position. Furthermore, failure of the hydraulic system would permit the valve to fly open. These disadvantages prevent any widespread use of direct cylinder operation.

The nut-and-screw-thread device is a relatively high-friction unit. Full load is transmitted through the stem threads into the valve operating nut. Appreciable friction on the thread surfaces calls for extra effort over and above that already established for the valve. The force developed by such screw thread construction can conveniently be calculated by means of a formula.

This formula, in most practical valve constructions, shows that the operating torque in ft lbs on the valve nut unit is about 1/100 of the pounds force developed in the stem.

Thread Friction Is Big Factor

With a rotating stem, the nut is fixed. Total friction is a combination of the thread friction, friction between valve disc and the end of the stem, and packing friction. In the case of a non-rotating stem, the nut is generally mounted on ball or roller bearings. Total friction is a combination of the thread friction, ball or roller bearing friction, and packing friction. In either case, thread friction accounts for more than 75 per cent of the total operating torque.

The fact that thread friction is so high often suggests various devices that might decrease it, making large valves easier to operate. A widely used device in some non-power applications is the ball-bearing stem thread as used in automobile steering mechanisms. Unfortunately, valve stem loads turn out to be so high that the allowable contact pressure of any reasonable number of balls is exceeded. Also, the requirement for extreme hardness on both ball rolling surfaces is not generally compatible with the other valve construction features. A further deterrant is the fact that too low a friction factor at the valve stem thread could allow a valve to automatically fly open. Some locking device would be required if the ball-bearing thread valve is to be held tight in the closed position.

Frequency Study Required

Before final decisions are made, knowledge of functional characteristics of valve operators must be added to knowledge of closing forces. Probably frequency of operation is the first factor to consider before selecting an operator. Allowable investment is quite different for a valve that might be opened only once a year than for a valve that might be opened and closed once a day.

Urgency of operating the valve must be considered, too. Large valves are opened and closed only according to a pre-arranged schedule in many instances. As much as a week's warning might be available that the valve must be closed at a certain time. In other cases, valves are subject to emergency closure, demanded in a matter of a few seconds. This prohibits any setup in which the foreman must find a man and then send him off to a remote location to close the valve manually.

Still another consideration is the

Fig. 5. Air-operated Impactogear combines low cost and faster operation

location of the valve. If it is easily accessible, there might be considerable difference between the cost of manual-operation and motor-operation. If the valve is in a very remote spot, manual-operation might call for platforms, scaffolds, stairways and railings that would decrease the cost differential between motor-operation and hand-operation. On the other hand, extension stems and chain wheels may achieve remote operation at relatively low cost.

A further consideration is whether the valve is always to be operated from a single station, or from several different stations at the same time.

About Motor Operators

Quite a number of different operating mechanisms are available to meet different requirements, ranging through a wide cost spread. Probably the most expensive, commonly used valve operator is the geared electric motor type, which closes the valve and cuts itself off when a predetermined torque has been developed by the motor. Such an operator is relatively expensive, both in equipment and electric wiring costs. Its advantages are tremendous, however.

For relatively little additional cost, it can be set up to be operated from several different locations. Open-and-close buttons can be installed in a control room, beside the valve, beside the boiler feed pump, plus any other desired location. Remote indicating devices can be attached at relatively low cost to show the position of the valve at any of the operating stations. By merely choosing a large enough motor, almost any operating speed can be achieved. There is no worry about power plant personnel becoming so tired that they cannot achieve complete closure of the valve within a specified time. The valve can be installed at almost any point in the power plant piping system, without regard to operating levels, access for service or proximity to other equipment. It is an ideal device for valves that are frequently operated.

Simple Handwheel Costs Least

At the other end of the cost scale is the simple handwheel attached directly to the operating nut or stem. This is certainly the lowest-cost operating device, having essentially none of the advantages of the motor drive. The obvious disadvantage arises from the high operating torque. In some of the typical examples already cited, the torque requirements on a simple 36-in. diameter wheel might call for 150 lbs pull on the rim of the wheel to turn the valve from open to close. As much as 1000 to 2000 lbs pull would be needed on the rim of the wheel to seat the disk. Thus, 20 men would have to crowd around the rim of this simple wheel to achieve the 2000-lb pull.

A common solution to this high-torque problem is to equip the valve with a gear system. Gears, of course, change the operating ratio down to a point where the pull required on the rim of the wheel is within the capability of one or two men. The number of revolutions required for given travel goes up corresponding to the change in gear ratio. In addition, friction losses in the gear train increase. So, the forces required may go down, but the total work effort goes up.

The peculiar force requirements of opening and closing a valve call for relatively low forces through a long distance, in going from open to close, followed by high forces through a short distance at the point of closure. This often suggests a gear shift device. Low gear would be used for developing the tight seating force and high gear for operating from open to close. The general idea is sound in theory. But, in practice, the cost of such a gear shift makes the idea impractical. Few devices of this type are available.

A mechanism with continuously variable gear ratio . . . giving high speed in the open position and low speed (with high force) in the near-closed position . . . is partially achieved by what is known as a *toggle construction*. A moderate number of large, high-pressure valves have been built, from time to time, with variations of toggle-type operating mechanisms. Such constructions are considerably preferred over a plain manually-operated wheel. But in large, high-pressure valves, toggle-type operators leave something to be desired. Total number of revolutions required from open to close tends to be relatively high, and the work load tends to be more than a single man can perform, even over periods as long as 15 or 20 minutes.

Still another form of gear shifting has been used on large, high-pressure valves for many years . . . the Impactor handwheel. It, in effect, is a directly-coupled handwheel on the valve operating nut, with a backup feature. This feature permits striking an impact blow. The valve is turned from open to close by continuously rotating the handwheel. No gearing or other magnification of the torque is applied. When the valve is approximately seated, the handwheel is backed off about ⅓ of a turn and then rapidly brought forward. Two anvils on the wheel strike a cross arm secured to the operating nut. The momentum of the spinning handwheel generates almost an infinite operating torque for an instant. By applying a series of such blows to a typical 36-in. Impactor handwheel, one man can develop torque equivalent to 5000 ft-lbs, with no gearing or other magnifying mechanism. This type of valve operator has proved very efficient in many years of high-pressure power plant use.

A recent development that bridges the gap between motorized operation and hand operation is the Impactogear operator. This is a modification of the widely used Impactor handwheel. A gear-and-pinion assembly is added to the valve operating construction. The pinion shaft projects from the side of the valve, below the handwheel. The pinion is turned by a portable motor, such as an air-driven wrench. A wrench on the end of one air hose could serve several valves. Gearing gives a 12 to 1 reduction.

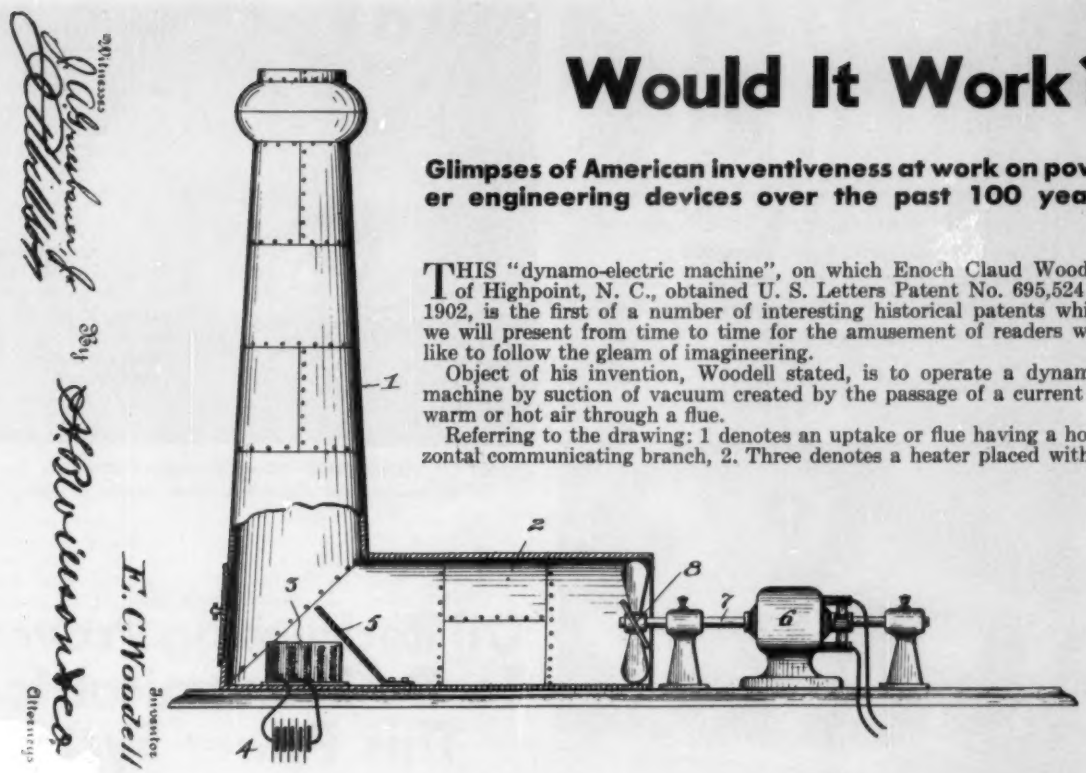
A portable air wrench putting out 50 ft-lbs of torque will generate 600 ft-lbs of operating torque at the valve operating nut. This is sufficient to carry most large, high-pressure valves from full open to full close or back in one minute. Power plant operators are relieved of the backbreaking work of turning the valve handwheel through many revolutions with sustained effort that might range from 50 to 150 lbs pull on the rim of the wheel. After a valve equipped with an Impactogear operator has been brought near the seat, a series of impact handwheel blows are struck by hand to achieve the 3000 or 4000 ft-lb closing torque necessary for tight seating. Thus, one man can close a large, high-pressure valve in a reasonably short time without excessive manual effort. This does not replace the electric motor operator by any means. Though lower in cost, it does not offer remote operation or remote indication.

In the final analysis, the best choice of valve operator is dictated by recognizing torque requirements of the valve, the functional features of the many types of operators available, and the needs of the installation.

When considering relatively expensive electric motor operators, a very uneconomic selection might be made using highest possible test pressure as a criterion. In this case, valve purchaser and valve supplier must carefully study the exact application, and the maximum differential, that will be applied to the valve seat. Often, several thousand dollars can be saved by sizing the motor operator, exactly for the job application. THE END

Would It Work?

Glimpses of American inventiveness at work on power engineering devices over the past 100 years



THIS "dynamo-electric machine", on which Enoch Claud Woodell of Highpoint, N. C., obtained U. S. Letters Patent No. 695,524 in 1902, is the first of a number of interesting historical patents which we will present from time to time for the amusement of readers who like to follow the gleam of imagineering.

Object of his invention, Woodell stated, is to operate a dynamo-machine by suction of vacuum created by the passage of a current of warm or hot air through a flue.

Referring to the drawing: 1 denotes an uptake or flue having a horizontal communicating branch, 2. Three denotes a heater placed within the horizontal branch 2, preferably an electrical heater connected up with a suitable number of batteries, 4.

Five denotes an inclined deflector arranged in the horizontal branch 2 to one side of the electric heater, so as to deflect the heat directly into the vertical part 1 of the flue, thus drawing through the open end of the branch 2, currents of air, which are entrained with the heated air from the electric heater and pass up out of the upper end of the flue or uptake 1.

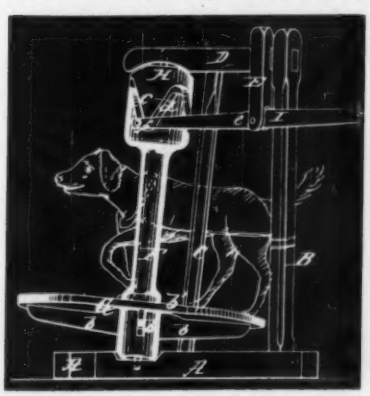
Six denotes a dynamo-electric machine, to the armature shaft 7 of which is fixed a fan or propeller wheel 8, which projects into the open end of the horizontal branch 2 of the flue.

In operation, Woodell explained, as the air is drawn through the open end of the horizontal branch 2 by the heated air passing upwardly through the uptake 1, the fan or propeller wheel will be rapidly rotated, thus rotating the armature shaft and generating electricity in the usual manner.

"While I have shown an electric heater for creating a current of air," Woodell commented, "I would have it distinctly understood that I do not wish to limit myself to this form of heater, as it is perfectly obvious that any other form of heater may be used and the same final result produced."

Horse power from dog power . . . if the dog is willing

THIS SCHEME for applying the power from a dog to the propelling of light machinery was patented in 1859 (No. 24,338) by Dexter C. Slater of Laurens, N. Y. Here's how it works:



Dog is placed on the wheel G, and rotates it by the movement of his legs. The cam H, as it rotates, gives a vibrating motion to the lever I, from which the power is taken.

Plane of the wheel G is at right angles to its shaft F, and consequently the wheel is inclined. On upper part of shaft F, cam H is formed of a hub *c*, having a zig-zag groove *d* made in it. Framing of wheel, shaft and cam may all be of wood, Slater explained, but groove *d* should be faced with metal strips to prevent wear.

A,A are sills connected near their front ends and having two posts B, C, attached to them near their ends, one part B being vertical and the other C, slightly inclined. Upper ends of these posts are attached to a horizontal bar D, and a pendant E is attached to D near its junction with post B. Upper end of the inclined shaft has its bearing in the bar D.

The wheel G is formed by having arms *b* pass transversely through the shaft and a circular platform *b*[1].

Lever I is secured by a ful[illegible] pin *e* in the pendant E, and allo[illegible] to work freely thereon. Inner end of this lever has a friction roller *f* attached to it, and this roller is fitted in the zig-zag groove *d* of the cam H.

As Slater commented: "The device is extremely simple. Composed of but few parts, power is transmitted from animal to machine with but little loss from friction."

However, incentive for the dog is not specified in the patent. Doubtless it depends on the dog.

In 5 years of operation, this purification system for acid oil from transformers, circuit breakers and regulators has processed 850,000 gal at a cost of 9 cents a gal. Savings on oil bill have paid for cost of installing the reclamation system

Fig. 2. Oil storage and reclamation plant of Public Service Co of Indiana, at Plainfield. Fred Willer at entrance

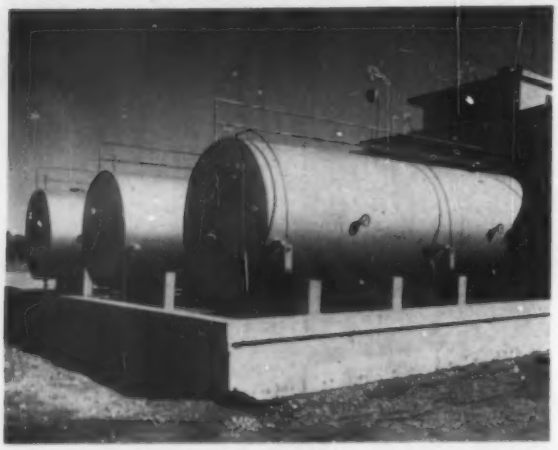


Fig. 1. Three storage tanks of 20,000 gal each are divided into parts for oil to be reclaimed, oil reclaimed, new oil

Oil Reclaiming Proves To Be Economical for This Power System

By **FRED W. WILLER** *

IN 1950, our company — Public Service Co of Indiana — centralized its headquarters in Plainfield, Indiana, a town 13 miles west of Indianapolis. In addition to a large, modern office building housing all departments, the property included a central garage, meter shop, store room and electric shop. From this center we project the service operations that maintain an electric system serving over 700 communities in 70 counties in Indiana with a maximum demand of 891,000 kva.

In 1953, this picture of centralized operation was enlarged to include a phase of maintenance that was in need of a new program. This was the matter of storage and the handling of replacement oil for transformers, circuit breakers and regulators, at the electric shop.

Our custom had been simply to buy oil in drums, to replace acid-laden oil with new, and then scrap the old. But with prices at 46 cents a gal for oil in drums, plus $3 for the drum, plus the high cost of handling drums, a more economical procedure for oil was clearly in order.

We knew that if we had adequate volume storage facilities we could buy oil in tank car lots at 32 cents a gal. Then what about the "dirty" oil which had to be replaced in equipment? Could this be purified and reused, with resulting savings? In 1950, we had in service a large quantity of oil that had become acid over years of use in older units of equipment. If this could be successfully reclaimed, we saw that we would be considerably ahead of the game on oil cost.

Accordingly, A. H. Arbuckle, test engineer for the company, studied the situation intensively and came up with a plan for an oil storage and reclaiming plant to be built as part of the Plainfield headquarters. This plant was built, at a total cost of about $150,000, and has been in operation 95 per cent of the time since it was completed in 1953. It was designed to handle a normal load of 100,000 gal of oil a year, but since 1953 has handled far more than that, in working on the large supply of oil-to-be-reclaimed which was on hand at the beginning.

We have now purified and returned to use about 850,000 gal of oil, at a cost of around 9 cents a gal, which does not include taxes, power or depreciation. This has made it possible to pay for the cost of the system out of savings in the oil bill.

Life tests show that the life of the reclaimed oil is roughly 60 per cent of the life of new inhibitor oil and greater than new uninhibitor oil. We are scrapping around 35,000 gal of oil a year that is too far gone to be reclaimed. This oil is shipped to our various generating plants for use in starting boilers.

It takes only one man to run the oil plant (combining other work in his schedule, such as repairing hydraulic line tools, making switch signs, etc); and last but far from least, we are convinced that this oil reclamation process is a big step forward in helping to eliminate failures on the system.

To keep down the insurance rate, the oil reclaiming plant and storage

* Electric Shop Supervisor, Public Service Co of Indiana

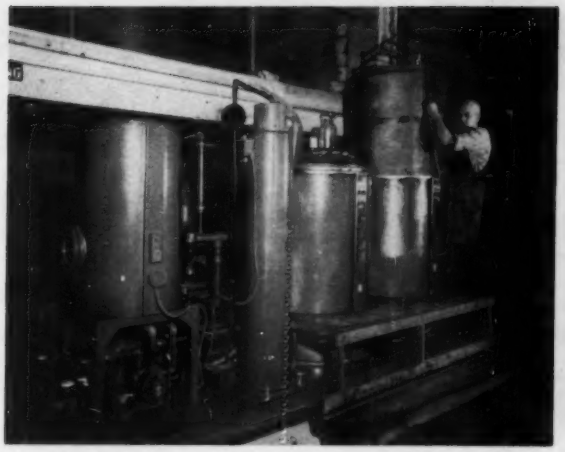


Fig. 3. Inside the plant, Willet Baumann changes the basket of earth-type filter in one of two elements of Purivac unit

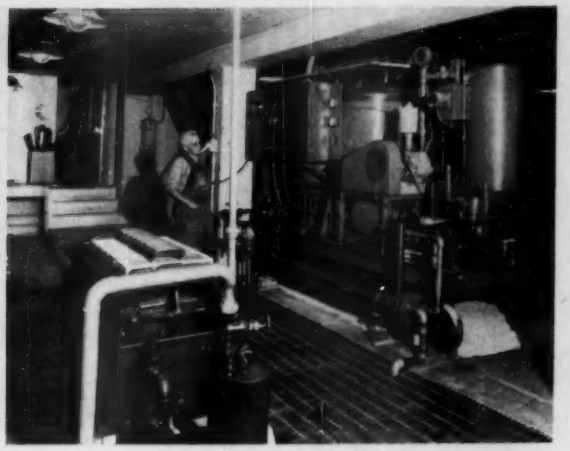


Fig. 4. Control side of Purivac. Heat exchanger (just above grating over headers to piping system) controls viscosity

tanks are located one-quarter of a mile back from the electric shop. A place is also thus provided for storage of paint and other flammable materials.

There is room for cleaning and filling oil drums; a dock where tankers can be loaded and unloaded; and a connection for unloading tank cars.

Immediately adjacent to the building on the north are three oil storage tanks, each of 20,000-gal capacity. Two of these tanks are divided into sections of 10,000 gal each. One tank is used for storage of new oil; the other for storage of reclaimed oil and oil to be reclaimed. The third storage tank is divided into four sections of 5000 gal each, two of which are used as working tanks in conjunction with the oil purifying unit that is inside the building. The other two sections of this third tank are used for the storage of oil to be reclaimed. Each section of each tank has its own 2-in. line that runs to the headers.

The oil plant is connected to the electric shop (where electrical equipment comes in for repair and overhaul) by four 2-in. lines. Three of these are for clean oil, one for dirty. The plant has a dirty and clean header for suction and discharge and each of the four headers is divided into sections to give flexibility. This makes it possible to pump dirty oil away from the electric shop, clean oil to the electric shop, empty or fill a tanker, and operate the reclaiming plant, at the same time.

Electric shop and reclaiming plant each are equipped with one 70 gpm pump and one 20 gpm pump, and all pumps can be controlled from the electric shop.

About one-third of the volume of oil to be reclaimed is brought in from over the system by a fleet of tankers; the rest comes from equipment being worked on in the electric shop. The seven tankers are of 2000, 4000, 5000 and 8000-gal capacity, four carrying 2000 gal. Before being stored, oil from tankers is put through a filter press to remove water and dirt.

We reclaim all oil from equipment that is brought into the shop, if it has a neutralization number of over 0.1. In the field, all oil testing at a neutralization number of over 0.2 is considered bad and will be brought in for reclaiming. For this field testing we use the Gerin kit for acidity tests.

Purifying Unit

Heart of the plant is the Purivac which purifies the oil. It is made by Indiana Commercial Filter Co, a subsidiary of Houdaille-Hershey Corp.

The unit includes dual earth-type purifiers, heating unit, vacuum dehydration and degasification unit, central control panel, pumps, motors, interconnection piping, valves and accessories.

Operation of this unit is two-stage: 1. oil from the storage tanks is pumped to the purifiers where it is passed through fuller's earth which removes colloidal carbon, organic acids, asphaltenes, sludge and dirt; 2. purified oil then passes through the heater unit and on to the dehydrating and degasifying chamber for complete removal of moisture and entrained air.

We normally use a batch size of 4000–4500 gal, and keep pumping it through the purifiers from one working tank to the other, until acidity tests at 0.05 neutralization number. This normally means pumping three to seven times to complete a batch. Besides the neutralization test, we make an interfacial tension test for purity. This must show over 35 dynes per centimeter length of the ring.

A heat exchanger connected directly in the intake of the Purivac assures proper viscosity, so that in cold weather, maximum performance from the purifying machine will be 500 gal per hr. When a batch has been completed we add an inhibitor (Shell Electocon No. 2) at a rate of 1 gal of inhibitor to 19 gal of reclaimed oil, and the oil is then placed in storage for future use. THE END

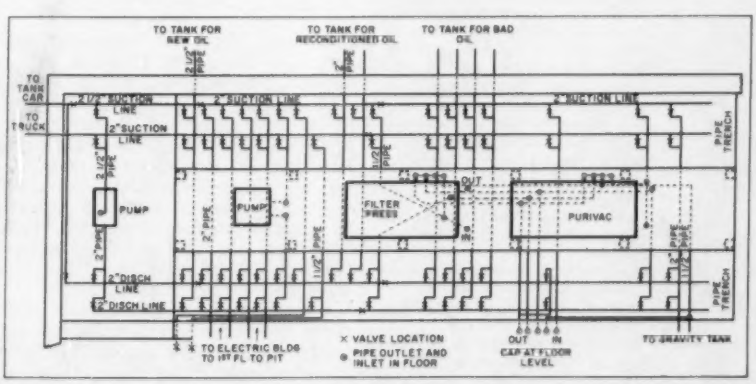


Fig. 5. Plan for piping system for oil reclamation plant. Four 2-in. lines connect the plant with the electric shop where equipment comes in for overhauling

You Can Figure Dollar Value of

By M. E. DeREUS*

SINCE all gain and loss factors of any heat system (including cost of heat) are readily scalable, the "money's worth" of insulation may readily be determined by using a simple formula of defined variables to produce a single index of worth "J."

This index can then be used in obtaining "yes" or "no" answers to the question, "Is an additional ½-in. thick increment of insulation economical for this job?" Use of the index does away with the long hours of computation formerly necessary, with minimum risk of error.

J-factor tables can be prepared for any kind of insulation, but for simplification only a single type will be considered here — a pre-formed, single-layer asbestos, refractory coated, with a thermal conductivity ranging from 0.32 at 100 F, to 0.72 at 900 F, mean, as shown by Fig. 1. Other thermal conductivities merely involve revisions of calculations.

Apart from considerations of safety, comfort, or the need for secondary equipment such as tracing lines, the answer to whether or not an increment of insulation is a good investment depends upon whether the heat which that insulation saves costs more over a reasonable period than the cost of amortizing the insulation.

These are the required factors of the problem:

S = Cost of Useful Heat defined as $/1,000,000 Btu, derived by dividing fuel cost by its calorific value and by the over-all system efficiency. (A different heat cost is sometimes used for different sections of the same job.)

A = Annual Rent or Amortization Charge for an investment with a present value of $1.00; for example, if an interest rate of 5 per cent is chargeable over a payment period of 10 years and compounded, the annual rent will be 0.130. (Annual rents which $1 will secure are displayed in tables on pages 2–29 of the 1936 edition of the Handbook of Engineering Fundamentals, edited by Ovid W. Eshbach, published by John Wiley & Sons.) Tax adjustments may be taken into account by using a suitable multiplier to allow the desired return on investment possible within the individual corporation's tax bracket.

Δ Btu = Heat Saved per ft of line by the addition of a ½-in. increment of insulation thickness.

ΔP = Catalog List Price of ½-in. increment of insulation expressed in $/ft.

VΔP = Installed Cost of ½-in. increment of insulation expressed in $/ft.

V = Ratio of Installed Cost to List Price only as these apply to a ½-in. increment of insulation.

N = Amortization Period, in years.

G = Annual Hours of Operation divided by 8760.

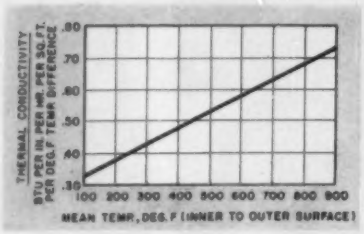


Fig. 1. Type of insulation considered here has thermal conductivity ranging from 0.32 at 100 F to 0.72 at 900 F

However precise the evaluation of these enumerated factors may be, any computation of economic worth of insulation is potentially misleading unless applied within the context of good engineering judgment.

No insulation is worth much if its conductivity is so high that inordinate thicknesses are needed. Nor can its benefits be properly assigned over an extended period unless the insulation has the heat resistance and structural permanence needed to withstand the rigors of the service to which it is put.

While not explicit to these formulas (though anticipated in VΔP), ease of installation with attendant savings in disruption or derangement of plant functions should be considered. Further, it should be noted that ease of installation bears even more heavily on plant functions during maintenance work on insulation.

Selection of an economical thickness of insulation for heat conservation requires that the cost of the applied increment of insulation be less than the value of the additional heat saved by that increment during the service life of the insulation, symbolically:

$$V\Delta P < \frac{(\Delta \text{Btu})\, S\, G\, N\, 8760}{1{,}000{,}000}$$

$$\text{If we let } J = \frac{1{,}000{,}000\,\Delta P}{8760\,(\Delta \text{Btu})}$$

then J can simply be used as an economic worth index, if index values for each pipe size and each increment of insulation are computed. (This is not difficult since manufacturers generally publish values of list prices and Btu loss for a particular insulation, but may be tedious since some 2000 individual computations are required to cover a range of insulation thickness from 1 in. to 6 in., and temperatures from 200 to 1200 F for pipe sizes from ½ in. to 24 in.).

Customarily, J indices are computed only once and then displayed in tables such as that shown by Table I, reproduced from the publication, Unibestos Insulation, No. F76–321, by Union Asbestos & Rubber Co. This table also includes surface temperatures (ST), heat loss to an ambient 75 F, still air (Btu), and a percentage efficiency of the heat saved by the insulation (item E in table). Separate tables of this type must be computed for each different insulation considered, and for each pipe size.

A generalized picture of the economic limits for J is displayed in Table II. When the derived limit of J is less than 2.0, surface temperatures, in terms of safety and comfort, may become the controlling factor governing insulation selection.

For straight line amortization it is economical to add that increment of insulation for which

$$J > \frac{N\,S\,G}{V}$$

As a typical example, if the design conditions for a particular job are such that: the amortization period is 10 years, N = 10; the cost of useful heat is $.50/1,000,000 Btu, S = .50; the annual operation time is 8000 hrs, G = 0.91; and the best estimate of the in-place cost of an increment of insulation is two times the list price of the insulation, V = 2.0; then it is only necessary to make the one computation —

$$\frac{N\,S\,G}{V} = \frac{10 \times .50 \times 0.91}{2.0} = 2.3$$

after which the economic thickness of insulation for heat conservation for all pipe sizes can be selected by inspection of tables, such as Table I, which show the economic index, J.

For example, in this case, inspection of Table I for a 3-in. pipe at 500 F shows that 2 in. of insulation with a J factor of 2.0 would be economical, but that 2½ in. of insulation with a J factor of 2.7 would not be economical. Accordingly the 2 in. thickness would be selected for these conditions, but if the pipe temperature were 600 F, then 2½ in. thickness with a J factor of 2.1 would be preferable.

Where the investment in insulation must yield a return, $\frac{1}{A}$ is substituted for N, and it is only economical to use that increment of insulation for which:

$$J < \frac{S\,G}{V\,A}$$

In greatly simplified form, selection of the economical increment of insulation may be reduced to a series of J factor tables (also given in Unibestos Insulation). These are for insulation with the thermal conductivity shown in Fig. 1. Preparing tables for any other insulation would require factoring for both changes in thermal conductivity and differences in list price.

continued on page 74

*Technical Associate, Union Asbestos & Rubber Co

Insulation By This Simple Method

Pipe Temperature, F			200				300				400				500				600				700			
Temp. Diff., F To Ambient Air			125				225				325				425				525				625			
INSULATION Thickness in.		List Price	ST	BTU	J	E	ST	BTU	J	E	ST	BTU	J	E	ST	BTU	J	E	ST	BTU	J	E	ST	BTU	J	E
Nom.	Actual																									
Bare	0.0	...	200	267	...	...	300	601	...	...	400	1058	...	...	500	1664	...	...	600	2460	...	...	700	3456	...	...
1	1.03	.45	92.8	42.0	.23	84.3	108	82.5	.10	86.4	123	127	.06	88.0	138	176	.03	89.4	154	233	.02	90.5	171	294	.02	91.5
1½	1.56	.76	86.8	32.2	3.6	87.9	97.0	62.4	2.0	89.6	108	96.5	1.2	90.9	119	135	.86	91.9	130	177	.63	92.8	142	223	.50	93.5
2	2.06	1.15	83.8	27.1	8.7	89.9	91.5	52.5	4.5	91.3	99.7	81.1	2.9	92.3	108	113	2.0	93.2	117	148	1.5	94.0	127	187	1.2	94.6
2½	2.56	1.50	...	...	...	...	88.0	45.7	5.9	92.4	94.7	71.1	4.0	93.3	102	98.3	2.7	94.1	109	129	2.1	94.8	117	162	1.6	95.3
3	3.06	1.90	...	...	...	...	85.8	41.2	10.2	93.1	91.3	63.7	6.2	94.0	97.1	88.7	4.8	94.7	103	116	3.5	95.3	110	146	2.9	95.8
3½	3.59	2.35	...	...	...	...	...	...	...	...	88.6	57.7	8.6	94.5	93.5	80.4	6.2	95.2	98.9	106	5.1	95.7	104	133	4.0	96.2
4	4.09	2.85	...	...	...	...	...	...	...	...	...	...	...	...	91.0	74.7	10.0	95.5	95.5	97.9	7.1	96.0	100	123	5.7	94.4

Pipe Temperature, F			800				900				1000				1100				1200			
Temp. Diff., F, To Ambient Air			725				825				925				1025				1125			
INSULATION Thickness in.		List Price	ST	BTU	J	E	ST	BTU	J	E	ST	BTU	J	E	ST	BTU	J	E	ST	BTU	J	E
Nom.	Actual																					
Bare	0.0	...	800	4714	...	...	900	6253	...	...	1000	8156	...	...	1100	10457	...	...	1200	13194	...	...
1	1.03	.45	187	360	.01	92.4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1½	1.56	.76	154	274	.41	94.2	167	329	.01	94.7	179	386	.01	95.3	...	...	...	...	...	...	...	...
2	2.06	1.15	137	229	.99	95.1	147	274	.81	95.6	157	323	.71	96.0	167	374	.01	96.4	177	430	.01	96.7
2½	2.56	1.50	125	199	1.3	95.8	133	238	1.1	96.2	141	280	.93	96.6	150	326	.83	96.9	159	374	.71	97.2
3	3.06	1.90	117	179	2.3	96.2	124	214	1.9	96.6	131	252	1.6	96.9	138	291	1.2	97.2	146	335	1.2	97.5
3½	3.59	2.35	110	162	3.0	96.4	116	194	2.6	96.9	122	228	2.1	97.2	129	265	2.0	97.5	135	304	1.7	97.7
4	4.09	2.85	105	150	4.8	96.8	111	180	4.1	97.1	116	212	3.6	97.4	122	246	3.0	97.6	128	282	2.6	97.9
4½	4.50	3.50	103	143	10.6	97.0	108	172	9.3	97.2	113	202	7.4	97.5	118	235	6.8	97.8	123	269	5.7	98.0

Table I. Usually, J indices are computed only once, then displayed in a table like this. Also included are surface temperatures (ST), heat loss (BTU) per hr per lin ft, efficiency (E) for 3-in. pipe insulation. Each pipe size needs its own table

Cost of useful heat, $/million Btu, S* Annual operation time, % year/100, G**	$0.50 1.00		$0.75 1.00		$1.00 1.00	
Ratio of in-place cost to list price of insulation increment, V	3.0	2.0	3.0	2.0	3.0	2.0
Service Life, N	Values of $\frac{S\,G\,N}{V}$, for straight line amortization					
6 years	1.0	1.5	1.5	2.2	2.0	3.0
8	1.3	2.0	2.0	3.0	2.7	4.0
10	1.7	2.5	2.5	3.7	3.3	5.0
12	2.0	3.0	3.0	4.5	4.0	6.0
14	2.3	3.5	3.5	5.3	4.7	7.0
17	2.8	4.2	4.2	6.4	5.7	8.5
20	3.3	5.0	5.0	7.5	6.7	10.0
25	4.2	6.2	6.2	9.4	8.3	12.5
33	5.5	8.2	8.2	12.4	11.0	16.5
Annual Rent or Annual fixed charge, A	Values of $\frac{S\,G}{V\,A}$, for declining balance amortization					
33 per cent	0.5	0.8	0.8	1.1	1.0	1.5
25	0.7	1.0	1.0	1.5	1.3	2.0
20	0.8	1.3	1.3	1.9	1.7	2.5
17	1.0	1.5	1.5	2.2	2.0	3.0
14	1.2	1.8	1.8	2.7	2.4	3.6
12	1.4	2.1	2.1	3.1	2.8	4.2
10	1.7	2.5	2.5	3.7	3.3	5.0
8	2.1	3.1	3.1	4.7	4.2	6.3
6	2.8	4.2	4.2	6.3	5.6	8.3

* Cost of useful heat will be $1.00 per million Btu when oil costing $0.10 per gallon with a calorific content of 141,000 Btu per gallon provides the heat at an overall efficiency of 71%.
** When annual operation time is less than 8760 hrs per year, multiply tabulated values by the appropriate proportion, i.e., for operating time of 8000 hrs/yr, G = 8000/8760 = 0.91.

Table II. This table gives a generalized picture of the economic limits for J. Where the derived limit of J is less than 2.0, surface temperatures may become the controlling factor which will govern selection of the insulation

Obviously, too much insulation can be just as uneconomical as too little, and rule-of-thumb decisions are a needless risk now that scientific selection has been reduced from a matter of possibly days to a matter of minutes. It is interesting to note that as increased costs, due to inflationary pressures, place more emphasis upon the saving of every possible dollar, the economic thickness of heat insulation will remain the same if the cost of useful heat and the in-place cost of the insulation both increase in the same proportion. (See Table II and compare the limits for J when S = 0.50, V = 2.0, and when S = 0.75, V = 3.0.)

J-factor tables represent another example of a manufacturer developing a time-saving short-cut for his own purpose and then making complete data available to everyone interested. Already in daily use by many major fuel consumers, and supplied in response to hundreds of requests from all parts of the world, J evaluation of insulation economy has won established acceptance. THE END

Payback . . . Its Importance to Industrial Power

INDUSTRIAL POWER requires an approach different from electric utility power, with more attention paid to capital costs than to operating costs.

This fact was spelled out in a concrete way by R. K. Patterson of Charles T. Main, Inc, speaking at the National Power Conference in Boston. As Patterson points out:

For anyone interested in industrial energy the most important thing to know about a particular company or industry is the ratio of fixed assets to total assets. A high value of this ratio indicates an industry which has installed quite a bit of machinery and which can expect a fairly long payback time on this machinery.

How is payback calculated and what does it mean? Consider the totals of all manufacturing companies for 1956. As Patterson explains, if we deduct costs and expenses, exclusive of depreciation, from sales revenue we get a figure of $37 billion added by plant for that year. This was made possible by a plant investment, or fixed assets, of $79 billion. Dividing the latter by the former, we find 2.1 years payback average for manufacturing that year. This corresponds to a capital charge of 47.5 per cent.

For the electric utility companies in 1956, by the same type of calculations we find a payback of 6.5 years or a capital charge of 15.4 per cent.

Now, the shorter the payback time for the capital investor in plant for a particular company, the harder it will be to justify new power-supply equipment. As Patterson says, in boom times they want all their annual depreciation money for building new plant, or for new machinery to increase output — not to obtain cheaper steam or electricity. In slack times, if not too bad, more depreciation money is available for power-supply equipment. With longer payback time, it is easier to justify.

Variations in fuel costs are relatively unimportant in the face of a great range in capital charge, Patterson says. Utilities' most modern plants run in the order of 9000–9500 Btu per kwh. Assuming fuel at 27 cents per million Btu, the fuel charge would be about 2.6 mills per kwh. A manufacturing plant can easily attain 14,000 Btu per kwh in a small condensing electric plant. At the same fuel cost as above, this amounts to 3.8 mills per kwh. For manufacturing's by-product electric plant with a heat rate of 5000 Btu per kwh, fuel charge would be 1.4 mills. This variation of 1.2 mills up or down from the best utility plants is of no consequence compared with the great range in capital charges produced by differences in payback time.

The shorter the payback time, Patterson says, the more important will be capital investment and the less important will be generating equipment efficiency.

Industries, although their generating plants are smaller, do not have to build a transmission system and they do not strive for maximum efficiency. As a result, the investment cost for industry's electric generating plants is comparable to that for the utilities plant required to deliver power to industry.

In Patterson's analysis, by-product generation can often be justified by companies with a payback time of four years or longer. It is difficult, he says, for 3-year payback companies to justify unless they happen to be operating multiple shifts. Condensing electric generation is generally possible only for 5-year payback companies and then only with some combination of lower-cost fuel availability and high purchased-power rate.

Hydro power generation is possible only for companies with a long payback time, plus perhaps a factory remote from low-cost purchased power.

All of these are general statements. There will be exceptions.

Fig. 1. New generating plant of Central Maine Power Co is on Cousins Island in Casco Bay, at Yarmouth. Island site was chosen so plant would have easily accessible water transport for fuel oil supply. Island is connected with the mainland by a modern bridge. Setting is one of great natural beauty

How Yarmouth Gets Fully Automatic Water Treatment

By A. G. ZEIGLER*

THIS MODERN generating plant, recently completed at Yarmouth, Maine, by Central Maine Power Co, has many outstanding features, one of which is its fully automatic water conditioning installation. This equipment, designed and manufactured by the author's company, consists of an automatic dual-bed demineralizer system comprising dual cation and anion tanks, with single caustic and acid regenerant tanks and a waste neutralizing system.

The raw water supply is from wells and Yarmouth Water District, the ionized impurities of which are removed by the dual-bed demineralizer by means of ion exchange, supplying 50 gpm of make-up water to the steam generating plant. The system removes all ionized impurities, supplying an effluent equivalent to distilled water in regard to ionic contamination. This is accomplished, first, in the cation exchange unit, by an ion exchange material which exchanges, reversibly, hydrogen cations retained in the exchange material for ionized cations in the solution contacting the exchange material. In the anion exchange unit, the ion exchange material exchanges, reversibly, hydroxyl anions retained in the exchange material for those ionized anions contacting the exchange material as a result of their presence in the solution surrounding it.

Control components of the demineralizing system are mounted on a single control panel. In normal operation, a water meter associated with each exchange unit provides an electrical contact upon passage of a predetermined amount of water, actuating a reset counter, which is utilized as a batch totalizer. The cation reset counters receive impulses from Neptune water meters.

After receiving a predetermined number of impulses, counter contacts are tripped and the particular unit is put into position for regeneration. The counters are arranged so that they count out a predetermined but adjustable number of counts representing the volume of water conditioned by the exchange unit since its prior regeneration.

Point of actuating the reset counter is controlled by a knob connected to a black pointer. A traveling red pointer indicates progress of the count. "Zero" can be accomplished by manually superimposing the black pointer to superimpose the red pointer.

The exchange unit continues to function in the normal manner until the effluent water has reached a point where quality is deteriorating, when a conductivity indicator-controller indicates that fact, and automatically shuts down the unit.

*Vice President and General Manager, American Water Softener Co

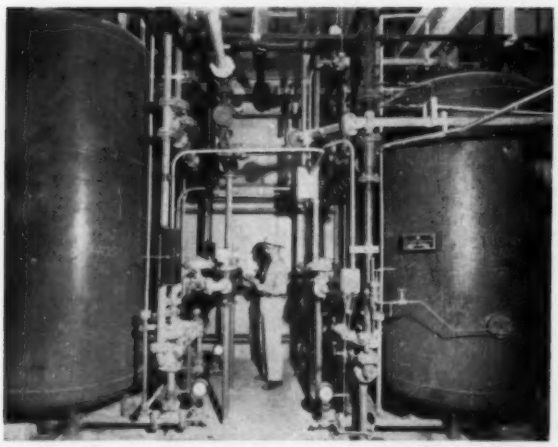


Fig. 2. View into aisle between exchange units. Anion exchangers are on the left, cation exchangers on the right

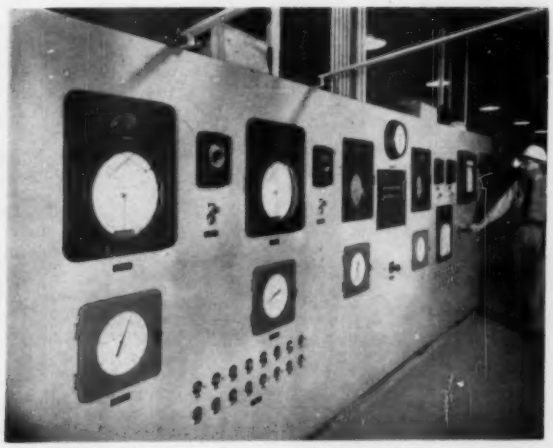


Fig. 3. Control units of the demineralizing system are mounted on single panel. Here operator positions a cation valve

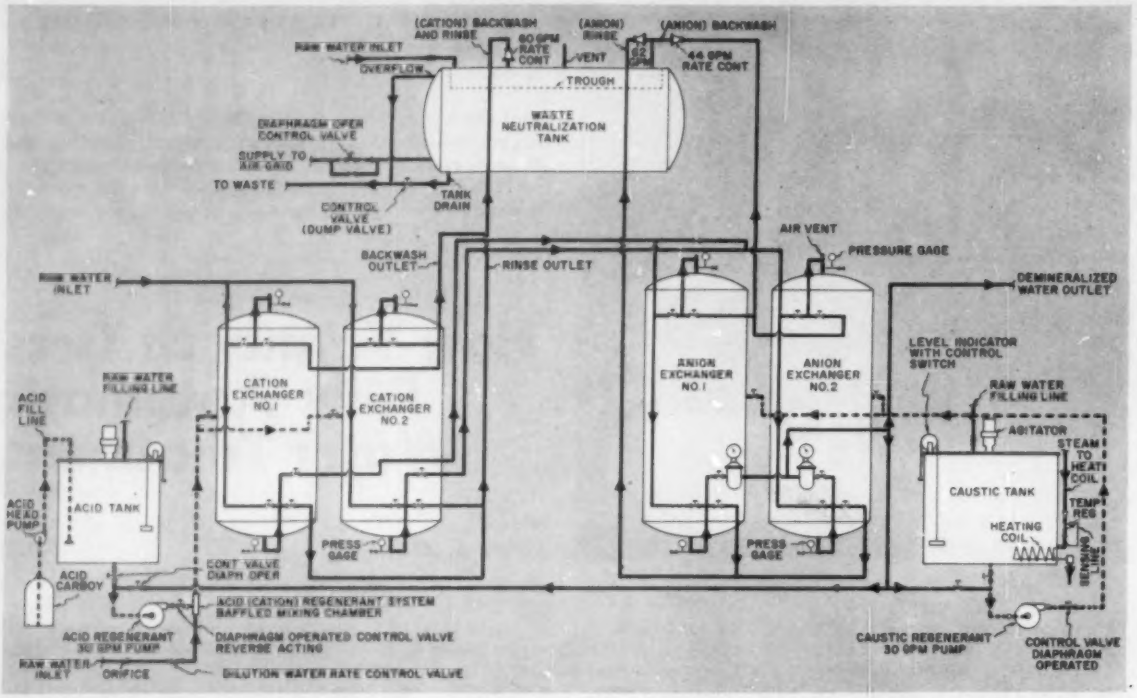


Fig. 4. Flow diagram showing piping connections of Yarmouth Station's demineralizing system. Waste neutralizing is feature

Program controller for this unit now goes into operation to accomplish the regeneration cycle and to actuate the interlock. The pilot-valve switches in this cycle controller are connected to the various process controls. A timing disc is notched to correspond with the exact time each control, or controls, and the corresponding valves are to be operated. Timing disc is rotated at a constant speed and positions the indexing cam which in turn rotates the operating cams and causes the pilot valves or switches to be opened and closed at the correct time, in the proper sequence. Each time the time-rider falls into a notch on the disc, the indexing cam is advanced to the next station.

The exchange units are set in series train or in pairs. When operated in series, the regeneration of an anion unit is always followed by its corresponding cation unit and, through a series of relays, there will be actuated the proper solenoid operated air valves to permit regeneration of the proper units. When operated in pairs, the units may be regenerated individually.

In a typical regeneration of an anion unit the initial motion of the timing disc advances to the first notch, engaging a set of cams which, operated by the cam shaft motor, open a series of pilot valves which direct air pressure to the proper diaphragm valves sending backwash water through the unit. Cams remain at rest while the timing disc times the operation.

At the next station on the timing disc, through the proper cams, the valving arrangement is reset and a pump is operated to carry the caustic regenerating solution to the anion tank. The low level switch on the caustic tank energizes valves to admit flushing water to enter the anion tank, displacing the caustic.

In a similar manner, by the operation of the time disc, the rinse is accomplished and upon occurrence of satisfactory quality the unit is returned to service.

As a precautionary measure, should the regeneration cycle fail to restore the ion exchange capacity to the proper level, the conductivity indicator-controller will indicate this deficiency and, after allowing a certain flow of water, will shut down the unit and operate alarm devices to attract the operator's attention to this condition.

An important feature is the waste neutralizing system, composed of controls and a neutralizing tank, providing for automatic neutralization of the waste solutions. An automatically controlled waste disposal valve permits discharge of only properly neutralized waste to the disposal system.

The system is interlocked with the demineralizing control equipment so that discharge of waste regenerant solutions to the neutralizing tank will be such that solutions in the tank will be maintained alkaline or neutral since the neutralizing tank is unlined.

An anion unit is always regenerated first and upon regeneration of a cation unit an air valve is automatically opened admitting air to the neutralizing tank, agitating the mixture of waste caustic and acid to maintain a completely and thoroughly mixed solution. Normally regeneration levels are such that the combined waste from the regeneration of a single anion unit and a single cation unit will be in an alkaline state.

However, pH control is maintained by limit switches which actuate supplementary control equipment to inject acid, or, if necessary, caustic to neutralize the waste solution. A reset timber provides for continued agitation of the neutralized waste for a fixed time interval to assure that final neutralization has been accomplished. The pH control-switches monitor the agitation over the entire period. If necessary, a repeat cycle timer takes over to repeat the mixing process. When the correct pH has been maintained for a set period the dump valve opens to dispose of the neutral waste material.

Relays, interconnected between the control circuits of the waste neutralizing system and the circuits of the demineralizer automatic control system, will not allow regeneration cycles to proceed unless the neutralizing system can receive the waste solutions.

While this entire demineralizing plant is set up for fully automatic operation, provision is made for semi-automatic control with annunciators, pilot lights and warning signals to guide the operator in progression through the regeneration and waste disposal operations. THE END

Measuring X-ray Diffraction Speeds Scale Analysis

By VERN W. PALEN*

COMPLEX ANALYSIS problems which involve scale deposits from boilers and heat exchangers are handled speedily and effectively with the aid of X-ray diffraction. Samples of deposits are checked to determine their chemical constituents and structure in order to select the proper solvent for use in cleaning operations.

X-ray powder camera techniques have been used to analyze scale-forming deposits for more than a decade. Recently, the X-ray Diffractometer has been applied to this work, since it provides greater accuracy and speed, and eliminates variables such as film shrinkage.

Many different chemical compounds have been found in scale deposits and Table I shows typical examples. Mineralogical names are given because they are more generally used than the chemical terms. Deposits peculiar to specific industries are encountered occasionally and are readily identified by theX-ray method also. Ferric gluconate ($FE(CH_2OH(CHOH)_4COO)_3$) as a process side deposit in the sugar industry is an excellent example.

First and most important step in the identification of a deposit involves sample preparation. Approximately one gram of the deposit is ground so it will pass through a 200-mesh-screen. This requires special care because incomplete grinding and screening may cause a separation of refractory components and permit them to escape detection.

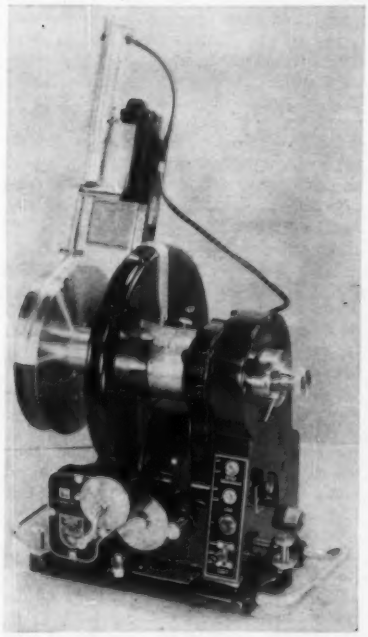


Fig. 1. Wide-range Norelco goniometer used in studies of X-ray diffraction

Sample powder is then packed into a holder which fits into place on the goniometer, Fig. 1. In cases where the sample size is too small for the holder, the powder camera may be used since it requires only a few milligrams of the material. When the X-ray beam strikes the powder, the rays are diffracted. By means of a detector and electronic circuits, the angle of diffraction and intensity are recorded on a strip-chart.

Typical X-ray diffraction charts are shown in Fig. 2. They were obtained from samples containing various amounts of iron oxide and metallic copper, as shown. Variation in peak height with concentration is apparent also, iron oxide peaks being marked A and copper peaks B. This permits a quantitative determination of the constituents present as well as their qualitative identification.

Accuracy is about 10 per cent of the amount present. In cases where higher accuracy is sought, the goniometer may be set manually on a given peak and intensity can be measured by recording pulses over an extended period of time.

Some insight into the efficiency of the scale removal treatment can be obtained by analyzing the drained solvent and comparing it with the X-ray analysis of the deposit. Solvent analysis is made spectrochemically for the different elements in the solvent.

Frequently, the presence of a particular element provides a basis for calculating the quantity of a given scale component dissolved. This can be seen from Table I if we consider a mixed deposit of acmite, analcite and pectolite since each has at least one element not present in the other two materials. Thus, an analysis of the solvent for iron, aluminum and calcium would be indicative of the relative amounts of acmite, analcite and pectolite dissolved, respectively.

Table I. Typical deposits readily identified by means of X-ray diffraction

Name	Formula
Acmite	$Na_2O.Fe_2O_3.4SiO_2$
Analcite	$Na_2O.Al_2O_3.4SiO_2.2H_2O$
Pectolite	$Na_2O.4CaO.6SiO_2.H_2O$
Hydroxyapatite	$Ca_{10}(OH)_2(PO_4)_6$
Serpentine	$3MgO.2SiO_2.H_2O$
Hematite	Fe_2O_3
Magnetite	Fe_3O_4
Copper	Cu
Alpha Quartz	SiO_2

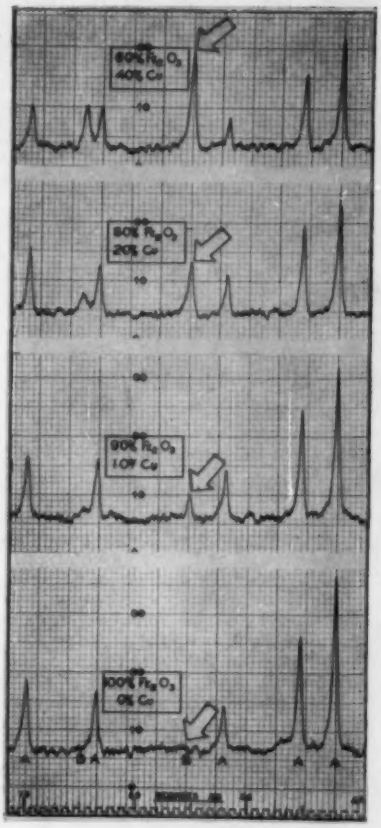


Fig. 2. Diffractometer charts showing variation in content of chosen samples

Correlations of this type have been found very useful in predicting the extent of success achieved in the cleaning operation. The following case histories are presented to illustrate the use of such correlations, their value and limitations.

Case 1 covers an X-ray analysis showing mixture of hematite (Fe_2O_3), hydroxyapatite ($Ca_{10}(OH)_2(PO_4)_6$) and serpentine ($3MgO.2SiO_2.H_2O$).

The spectro-chemical analysis of the used solvent for iron, calcium and magnesium provided a means of correlating the quantity of each material removed. When the results of the solvent analysis were reported in terms of the original compounds found by X-ray analysis, the relative amounts of each component were about the same by both methods. This indicated that the solvent had acted on all components of the deposit and could be expected to remove it.

Visual inspection of the unit to-

* Philips Electronics, Inc

gether with observations of its operating efficiency provided the ultimate basis for judging the treatment. While the importance of the solvent analysis should not be underestimated it must be remembered that the results are relative. They cannot be expressed in terms of a percentage of the total deposit removed since this latter quantity is rarely, if ever, known very accurately.

In Case 2, pectolite ($Na_2O.4CaO.6SiO_2.H_2O$), analcite ($Na_2O.Al_2O_3.4SiO_2.2H_2O$) and alpha quartz ($SiO_2$) were found in the deposit by X-ray analysis. Solvent analysis for calcium and aluminum showed that pectolite and analcite had been removed in approximately the same proportions as indicated by the X-ray analysis. Since silicon was present in all three components, the quantity of alpha quartz removed could not be determined. Small amounts of dissolved iron (probably from Fe_3O_4) and phosphate (probably from $Ca_{10}(OH)_2(PO_4)_6$) were also to be found in the solvent.

Compounds containing these constituents were not found by X-ray analysis of the deposit.

Limit of Detection

Such lack of correlation between solvent analysis and X-ray analysis of the deposit is relatively common. This is generally due to a sample which is not entirely representative of the scale to be removed, or to failure of the X-ray analysis to detect the presence of the more minor components.

In general, components whose concentration is less than five per cent of the total are not expected to be recognized by X-ray analysis. The lower limit of detection is even higher for some compounds.

Case 3 involved a deposit containing about three-fourths magnetite (Fe_3O_4) and one-fourth copper (Cu). The solvent selected was of such a nature that only the magnetite would be dissolved. Consequently, analysis of the used solvent showed iron as the major element present, and a trace of copper.

Occasionally, one solvent will not satisfactorily remove every component of a scale deposit. This is not objectionable in cases where the undissolved components are disintegrated well enough to be flushed out of the unit. A new solvent, recently developed, will dissolve both iron oxide and copper. X-ray analysis played a prominent role in the research work leading to this development.

The cases mentioned give a cross-section of the types of deposits normally encountered. They illustrate situations where X-ray analysis has indicated both soluble and insoluble materials for a given solvent. For this reason, the use of X-ray analysis is important in planning chemical cleaning procedures.

Selection of the proper X-ray tube for analysis work is important. Table II gives the characteristics of tubes with different targets. Approximate filters are indicated in order to insure a monochromatic X-ray beam. The copper target tube is commonly used for general X-ray diffraction tests. Because most industrial deposits contain iron compounds which fluoresce, the copper target tube is not used for scale analysis.

Table II. Characteristics of targets in various X-ray tubes for deposit analysis

Target	Wavelength of Emitted Radiation (Angstroms)	Filter	Element Causing Fluorescence
Iron	1.9360	Manganese	Chromium
Molybdenum	0.7093	Zirconium	Yttrium
Copper	1.5405	Nickel	Cobalt, Iron

For most samples, the iron target tube is satisfactory because chromium compounds are usually not present in deposits. When chromium is present, a tube with a molybdenum target is employed. The molybdenum target produces fluorescence only with yttrium compounds thus it might seem best to use for all analysis work. This is not desirable, however, since this target does not separate the diffracted X-ray peaks as well as the iron target.

Figure 3 shows the Norelco X-ray Diffractometer. This instrument employs a counter tube which traverses a 180-degree semicircular path. Diffracted X-rays at characteristic angles are detected and intensities are recorded on a strip chart. The angular movement of the counter tube is reflected in the horizontal scale of the chart which shows intervals of one-half degree. This two-theta angle fits into the Bragg equation and allows the interplanar spacing of the crystal to be computed. The "d" value thus determined reveals the identity of the material.

Deposit samples must be analyzed not only for individual elements present but also to identify compounds and chemical structure of the scale. The latter information is essential in planning the treatment and in selecting solvents and application techniques for rapid and efficient deposit removal.

Fig. 3. Complete Norelco Diffractometer

For example, the mere identification of iron and oxygen would be insufficient since there are various forms in which iron oxide might be present. The X-ray method detects magnetite, hematite, geothite, hydrogoethite, lepidocrocite or some amorphous forms of hydrated iron oxide such as limonite. This allows fast, efficient selection of solvents for chemical cleaning operations.

Analyze Minute Samples

Frequently, it may be difficult to obtain a sizable sample of a deposit, or time will not permit a complete chemical analysis of the scale. X-ray techniques permit the service engineer to select the optimum solvent and cleaning procedure for the case in hand.

Similarity of equipment and operating conditions in industrial plants allows planning of cleaning operations on the basis of past experience in many instances. Nevertheless, it is well to recheck conditions periodically with X-ray analysis to make sure they have not changed.

Chemical scale-removal methods are used successfully on most types of industrial equipment containing many different deposits. Physical and chemical composition of the scale frequently differs markedly when compared to the liquids from which it is deposited. Due to operating temperature and other varying conditions, it is of prime importance that equipment undergo a thorough inspection prior to cleaning. Samples should be taken for laboratory examination and should come from areas where the deposit is heaviest and operating temperatures are highest.

In today's highly-competitive market, it is essential to maintain operating equipment at peak efficiency. Maintenance engineers are relying more and more on chemical cleaning to provide maximum operating capacity with a minimum of shut-down time. Experience has shown that scale deposits, if allowed to accumulate in boilers and heat exchangers, reduce efficiency and increase unit operating costs. Periodic removal of such deposits usually pays for itself through increased economy of operation.

The chemical solvent method of deposit removal is efficient and fast. It reaches inaccessible areas, eliminates costly dismantling and gives maximum protection to the equipment being cleaned. X-ray analysis plays a vital role. THE END

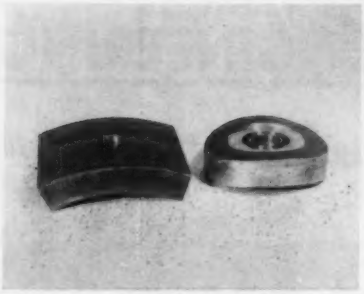


Fig. 1. One of the 5 by 5-in. squares which has been cut from steel cylinder and hole drilled. Finished plate right

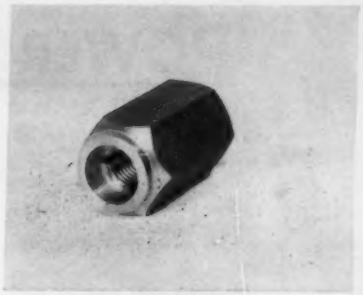


Fig. 2. Leak-off nut showing rabbet which acts as guide in centering plate on handhole plug. Note leak-off grooves

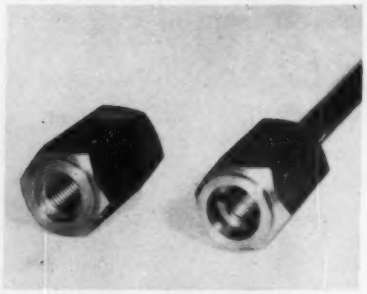


Fig. 3. Cap nut (left) is put on after plate is welded to header. Leak-off nut (r) shown with ½-in. pipe for steam

Fig. 4. Complete assembly: handhole plug, round steel plate which is welded to header, gasket, and the cap nut

Fig. 5. Complete assembly as it looks after installation on the header. This method of stopping handhole plug leaks has proved to be 100 per cent effective as a temporary application

Good Way to Stop Handhole Plug Leaks

By R. A. JOHNSTON *

WHEN A LEAK developed recently on one of the handhole plugs on our No. 2 unit, No. 4 boiler at the Lake Pauline Power Station, it was impractical to shut the unit down and drain the boiler to make the necessary repairs. The following method was used to make temporary repairs with the unit in operation.

A piece of 1-in. steel—14½ in. long and 36 in. wide—was rolled into a cylinder 11¾ in. inside diameter, with the seam left open. The 11¾ in. diameter is about the same as the diameter of the header in which the leaking handhole is located. This cylinder was cut on a band saw into 5 by 5-in. square pieces, and a 1 1/16 in. hole was drilled in the center of the square. About five of these pieces were then mounted on a mandrel and turned down in a lathe until they were round, with a 4½-in. diameter. Each piece was then chucked into the lathe and the gasket seat faced off.

A leak-off nut was then made from a piece of 2-in. hexagon steel bar about 4 in. long. This was drilled out all the way through and threaded inside to fit the threads on the handhole plug which is on the boiler. Three leak-off grooves about ¼ by ¼ in. were cut through the threads on the inside of the nut and a piece of ½-in. pipe was screwed into the other end of the nut to carry the leaking steam away while this equipment was being installed. The leak-off nut has a rabbet which fits into the gasket seat on the plate. This was machined to fit rather closely into the gasket seat and it serves as a guide to center the round plate over the handhole plug while it is being welded in place.

A cap nut was also made the same size as the leak-off nut and this is put on in place of the leak-off nut after the welding operation is complete.

To install this equipment on the boiler, the regular nut and yoke were taken off the handhole plug. With the boiler under 900-lb pressure, the plug will remain in place due to the pressure behind it. The round steel plate was then slipped over the stud on the handhole plug, and the leak-off nut was put on the stud and tightened.

The steam leaking from the handhole was then forced out through the grooves inside the leak-off nut and was carried away through the ½-in. pipe screwed into the back of the nut. The round plate was then welded directly to the header.

Only enough welding is necessary to seal off the steam leak, since the nut will be holding the plate firmly against the header.

After the weld was completed, the leak-off nut was removed and the cap nut put on. The cap nut was tightened down against the gasket and the leak was stopped.

In cases where a severe leak must be stopped, it may be necessary to put an asbestos gasket between the round plate and the header before the welding can be done. A gasket with a ¼-in. smaller diameter than the round plate will keep the leaking steam from coming out around the steel plate and interfering with the welding.

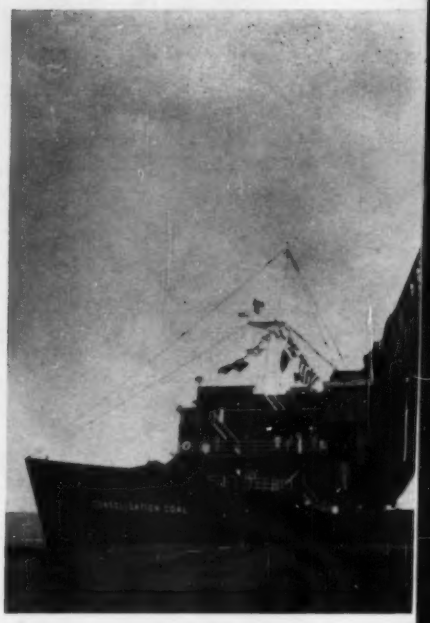
This method of stopping handhole plug leaks has been in use for several months and has been 100 per cent effective. This is only a temporary application and will be removed during the next scheduled shutdown. The plate will be removed from the header by cutting with an acetylene torch and the rough spots ground down. The handhole plug will be removed and a new gasket installed.

Several of the parts necessary to stop this type of steam leak are kept on hand for future use. THE END

* Chief Engineer, Lake Pauline Power Station, Quanah, Texas

POWER ENGINEERING'S

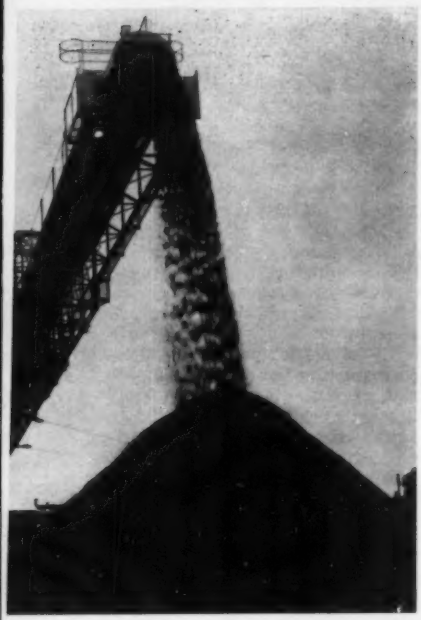
First self-discharging super collier built for ocean service is the S. S. Consolidation Coal, owned by Pocahontas Steamship Co. She made her maiden voyage recently from Hampton Roads, Va, to Salem, Mass, with coal for New England Power Co. Press of a button swings the 250-ft unloading boom ashore with the tip positioned over take-away system. Ship can discharge 24,000-ton cargo at rate of 1 ton per sec

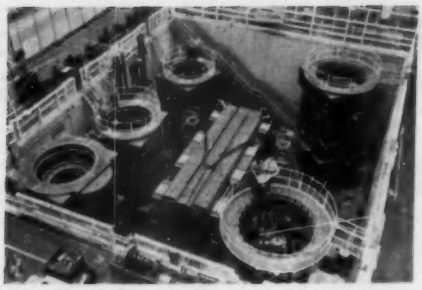


Liftslab hydraulic jacks are being used here to lift a 410,000-lb generator for the Public Service Board of San Antonio, Texas. In four hours of actual lifting time the generator was raised to a height of 24 ft 8 in. Six jacks on 14-in. flanges were used for this big power plant job

Red hot, this motor demonstrates its 950 F temperature by broiling a steak in seconds. It's a Westinghouse unit to test performance of a new system of insulation for motors, transformers and other equipment required to operate at high temperatures. Motors can operate usefully at 1200 F

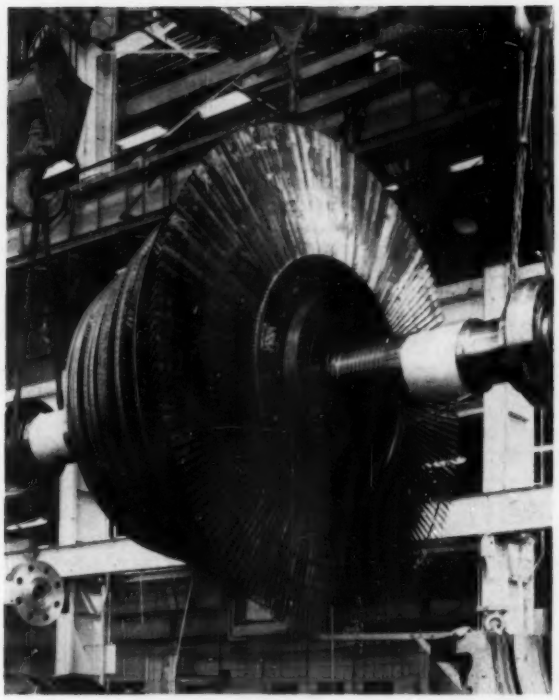
NEWS REEL



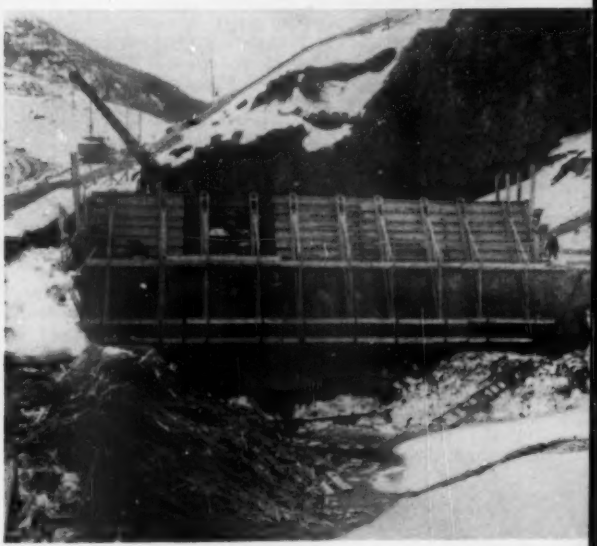


Stacking pit at G-E shows 6 steam turbine-generator stators on end to receive laminated punchings which make up the core of the stator

Newest and biggest of earth-movers is this 100-ft long machine with 130-ton capacity. It's LeTourneau's answer to dam building



Blades 44 in. long are contained in this huge low pressure spindle for Philadelphia Electric Co's Eddystone Station. Spindle goes into a 325,000-kw cross-compound superpressure unit, has over-all diameter of 14½ ft. Here the spindle is undergoing operating temperature testing at Westinghouse



All-steel forms, cantilever type and 7½ ft high instead of the usual 5 ft, are being used in the building of Bersimis River Dam near Forestville, Quebec Province, Canada. Dam is part of a project involving a powerhouse carved out of solid rock 800 ft underground. These larger forms, made by Blaw-Knox, are expected to cut construction time 30 per cent

Package Air Preheater Cuts Fuel Costs, Improves Processes in Industry

POWER ENGINEERING presents another in its series on what is being done to provide power engineers with better packages, to lower costs and improve operations. This preheater is a good example

By C. L. BROWN*

PREFABRICATION of air preheaters and rising fuel costs have started a trend in industry to greater use of heat-recovery equipment. This is producing the fuel economy and operating efficiency for industries in general, in their boiler or processing applications, that have been enjoyed by public utilities and large industrial plants for many years.

Standardization and simplification of design in prefabricated, or package, air preheaters provide small, self-contained units that operate on the same principles of heat recovery as large preheaters. They are for use with industrial boilers ranging from 25,000 to 250,000 lb per hr of steam.

In 1955, the year package preheaters were introduced, 27 of them were installed in industries. A year later, 43 more were installed. Last year, 50 package air preheaters were purchased. While the numbers seem few, they are impressive when it is remembered that the units are major equipment and represent an operation whose benefits and economies are virtually new and little known to industry generally.

Increase in use of preheating equipment was concurrent with a climb in fuel costs. Steady increases in prices of gas, coal and oil can be noted, and seem destined to continue. Cost of fuel has become and will continue to be a large item of operating expense.

A proper economic evaluation should be based upon the average fuel cost over the life of the equipment. A fair approximation may be obtained by taking the average rate of rise in the preceding period, over a long base.

In the following tabulations of comparative performance figures for steam-generating units with and without air-preheating equipment, the effect of preheated air can be evaluated quickly. The boiler sizes in the three case histories were selected to show the range of application of the package air heaters (Figs. 2, 3 and 4). They are, however, not the limits of air heaters.

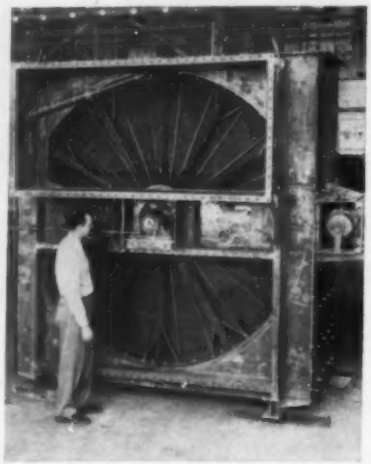


Fig. 1. Shop photo of a large package preheater, use of which is described

Fuel Savings

Efficiency of each boiler was increased appreciably. The increase on the 40,000 lb per hr unit was 5.08 per cent; on the 60,000 lb per hr boiler, 6.3 per cent; and on the 150,000 lb per hr unit, 5.76 per cent. Annual gross fuel savings can be estimated by reference to Fig. 5. Evaluation curves in Fig. 5 are based on 6000 hr per yr operation. In most cases operation of the boiler is closer to 8000 hr, which of course will increase the annual gross savings by roughly 13 per cent.

Further fuel savings may be achieved through use of lower-grade fuels, such as wood, lignites, peat and bagasse. For instance, to eliminate the expense of disposing of coffee grounds at an instant coffee plant, it has been found that preheated air materially aids the burning of such fuel. Various plants are burning coffee grounds either alone or in conjunction with another fuel. It has been found that more complete combustion and increased capacity result from the use of preheated air.

Preheated air permits the burning of lower-grade fuels containing sulphur and other objectionable material. The accelerated combustion due to preheated air reduces the amount of SO_3, formed in the flue gas, thus bringing to a minimum the corrosion and plugging problems caused by SO_3.

Higher temperature of the preheated air also reduces the incidence of unburned carbon leaving the furnace and entering the heat-recovery equipment. Carbon with its concentration of sulphuric acid aggravates the corrosion and plugging problems.

While fuel savings may be the chief impetus to greater use of preheating equipment, improved output and performance from preheated combustion air are other important contributing factors. The hotter flame obtained with preheated combustion air raises furnace temperature permitting more heat to be absorbed into boiler tubes or the heat transfer surfaces of process equipment. Service life of the fuel-burning

* Registered Professional Engineer, Technical Consultant, The Air Preheater Corporation

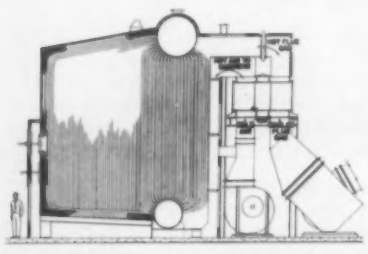


Fig. 2. Boiler and preheater similar to but larger than the example in Table I

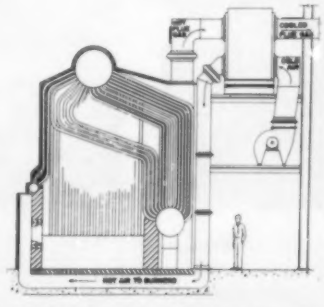


Fig. 3. Boiler and preheater described in Table II. Flow is horizontal here

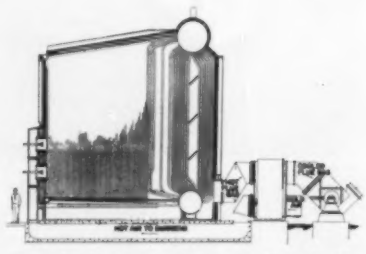


Fig. 4. Section of the larger boiler and preheater, set forth in Table III

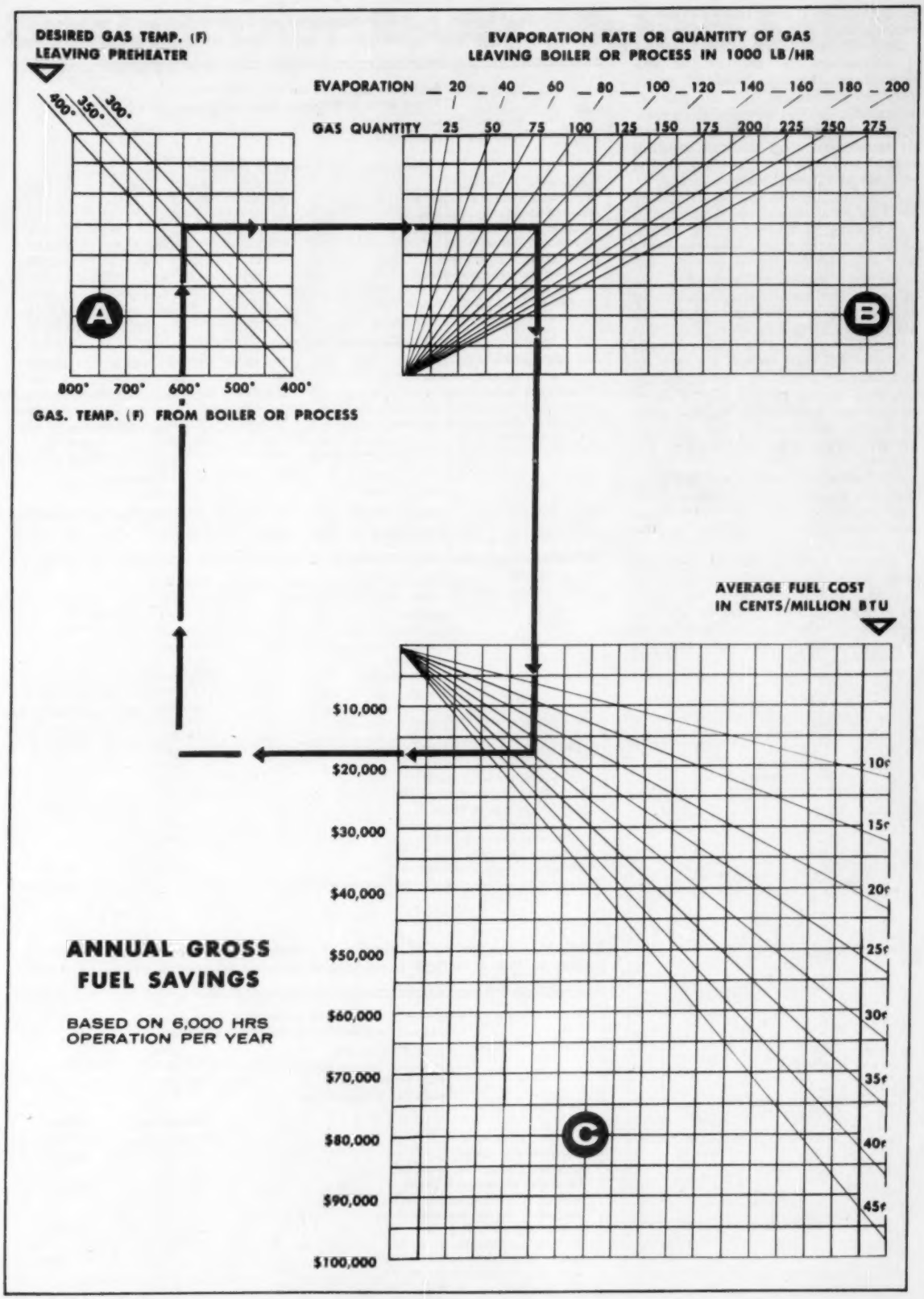


Fig. 5. Graphs for the determination of expected annual savings through the use of air preheaters, based on 6000 hours

equipment itself is increased through less slagging, plugging and corrosion.

Part of the increase in the number of preheaters in use can be explained by the expansion of heat-recovery equipment into the process industries. In the automobile industry the cost to maintain a constant air temperature on the wet sanding ovens and the bonderizing ovens represents a considerable expense.

However, by the use of a package air heater a considerable saving in fuel results, in addition to a means of obtaining the constant air temperature required for the drying process.

Figure 6 shows the general layout of an air preheater installation in an oven drying process in an automobile plant. Actual figures show that this particular installation reduced the annual fuel bill from $96,000 to $60,600 on the basis of 4420 operating hours, a saving of $35,400! This of course was in addition to the great advantage of obtaining the constant air temperature so beneficial to the process.

Preheated air is also used in a glass industry application to produce superior quality control per batch than was obtainable without the use of preheated air.

Readers desiring further information on package air preheaters, or copies of Fig. 5, may write the editor of POWER ENGINEERING, or jot Preheaters on the inquiry card to be found elsewhere in this issue. THE END

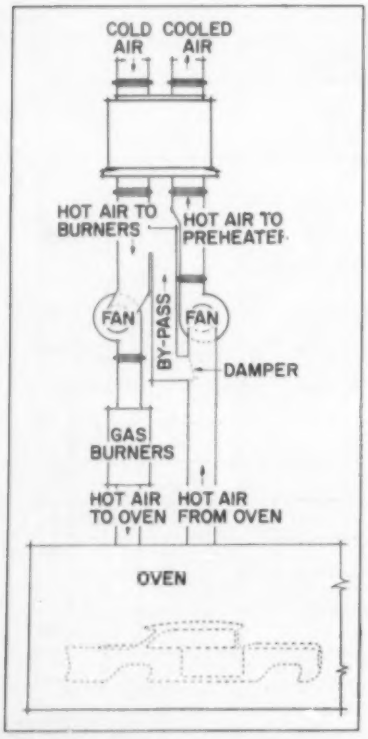


Fig. 6. Application of a package air preheater in an oven drying process

Table I. Actual figures on the performance of a boiler, similar to that shown in Fig. 2, in a Washington paper plant, before and after use of air preheating

Heat-Recovery Study, With and Without Air Preheating Oil-Fired Boiler With Vertical Package Preheater				
Pressure at superheater outlet, psig			200	
Feedwater temperature, F			210	
Performance with Package Air Preheater				
Evaporation, lb per hr	20,000	30,000	40,000	44,000
Air leaving preheater, lb per hr	19,200	30,000	40,800	45,000
Temp of air entering preheater, F	80	80	80	80
Temp of air leaving preheater, F	315	318	333	338
Gas leaving boiler, lb per hr	23,300	35,200	47,300	52,250
Temp of gas leaving boiler, F	460	500	555	570
Temp of gas leaving preheater, F*	280	311	352	364
APL through heater, 2000-ft el, in. WG	0.30	0.75	1.25	1.50
DL through heater, 2000-ft el, in WG	0.50	1.05	1.75	2.05
Overall efficiency of unit, per cent	86.40	86.37	85.68	85.40
Performance without Heat-Recovery Equipment				
Air entering furnace, lb per hr	19,800	31,200	42,800	48,000
Temp of air entering furnace, F	80	80	80	80
Gas leaving boiler, lb per hr	24,300	37,000	50,000	55,300
Temp of gas leaving boiler, F	475	510	565	580
Overall efficiency of unit, per cent	81.90	81.60	80.60	80.20

* Uncorrected

Table II. This heat-recovery study gives the results obtained by a preheater installation in a chemical plant in New Jersey. Installation is shown in Fig. 3

Heat-Recovery Study, With and Without Air Preheating Oil-Fired Boiler With Horizontal Package Preheater		
Operating Pressure, psig	160	
Steam Temperature	Saturated	
Feedwater Temperature, F	220	
	With Package Air Preheater	Without Heat Recovery
Evaporation, lb per hr	60,000	60,000
Air entering preheater, lb per hr	66,000	
Air leaving preheater, lb per hr	58,000	63,000
Temp of air entering preheater/boiler, F	80	80
Temp of air leaving preheater, F	374	
Gas leaving boiler, lb per hr	67,250	72,500
Gas leaving preheater, lb per hr	75,250	
Temp of gas leaving boiler, F	588	610
Temp of gas leaving preheater, F	350	
APL through heater, in. WG	1.65	
DL through heater, in. WG	2.25	
Overall efficiency of unit, per cent	85.70	79.40

Table III. Case history of the Texas refinery preheater installation shown in section in Fig. 4 reveals a significant increase in overall efficiency occurred

Heat Recovery Study, With and Without Air Preheating Gas-Fired Boiler with Horizontal Package Preheater		
Design Pressure, psig	300	
Operating Pressure, psig	255	
Steam Temperature	Saturated	
Feedwater Temperature, F	260	
	With Package Air Preheater	Without Heat Recovery
Evaporation, lb per hr	150,000	150,000
Air entering preheater, lb per hr	163,500	
Air leaving preheater, lb per hr	151,000	163,000
Temp of air entering preheater/boiler, F	80	80
Temp of air leaving preheater, F	361	
Gas leaving boiler, lb per hr	171,000	184,000
Gas leaving preheater, lb per hr	183,500	
Temp of gas leaving boiler, F	575	600
Temp of gas leaving preheater, F	352	
APL through heater, in. WG	2.60	
DL through heater, in. WG	3.70	
Overall efficiency of unit, per cent	81.72	75.96

Ground Your Power Station Safely

By ROBERT S. HORN*

In a revealing discussion of the hazards which may exist as a result of improper grounding, the author offers considerable food for thought, and points out methods of avoiding serious pitfalls

AS A STATION GROUND is for protection of life as well as property, it should be a matter of serious concern. If it is taken seriously it will be tested at regular intervals to determine if it has a low-enough resistance for its purpose.

It is recommended by some engineers that regardless of how good a grounding system is at the time of installation, it should consist of not less than two grounding elements (or groups of grounding elements) with switches that provide a means of disconnecting any one element (or group of elements) so that tests may be made without disconnecting the entire grounding system.

This is recommended because it is dangerous to measure the resistance to earth at a grounding electrode while it is in use, due to the fact that it might have to carry a large phase-to-ground fault current during the time it is being measured. Even a disconnected grounding electrode can can be dangerous during a period when ground-fault is conducted to earth by an adjacent grounding electrode if there is sufficient mutual resistance coupling between it and the adjacent electrode. (This is clearly illustrated by Fig. 9 which we will examine later.)

The study of adequate grounding is essentially a study of how much voltage drop will be present across the electrode-to-earth resistance of a station-grounding system during a lightning discharge or a phase-to-ground fault, and what effect this voltage drop could have on life and equipment.

Equivalent Circuits

Before discussing the voltage drop that may occur across an electrode-to-earth resistance, it seems that two points are worthy of mention. One of these relates to equivalent circuits, in which case the circuits are of the type that is commonly referred to as a network.

A three-terminal network may consist of three or more resistance elements that are connected between its three terminals in any conceivable way. Regardless of how complicated such a network may be, it has an equivalent network that consists of three resistances connected to three terminals in either a wye or delta arrangement.

An example of this is illustrated by Figs. 1 and 2. If these networks were put in proverbial black boxes, that is one in each of three boxes, with each network connected to three external terminals, there is no way of determining by electrical measurements which box contains, for instance, the wye network. If there were any way of doing this they would not be equivalent networks.

This complex three-way multiple path that connects three different grounding elements is represented on paper by a wye network consisting of three simple resistances.

The connection between the ends of the three resistances at the three-way junction in a wye network has a resistance equal to zero, of course. This point is of paramount importance when considering the circuit shown by Fig. 5 because in this diagram the broken line connecting ground-resistance symbols is intended to represent a path of zero resistance between them.

With reference to the second point considered, assume that the earth is homogeneous and that three ground rods which have a diameter of ¾ in. have been driven into it to a depth of 8 ft. There is a distance of 100 ft between two of them, and the third one is located 1000 ft or more from either one of the others. If the resistance were measured between these rods, it would be found to be

*Consulting Engineer. Mr. Horn is the author of the Lucas Graphs, so well received in the September, 1958, issue of POWER ENGINEERING

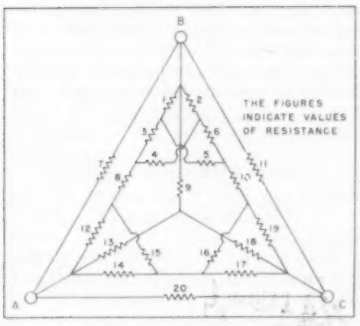


Fig. 1. Complex network of resistance elements, typical of grounding systems

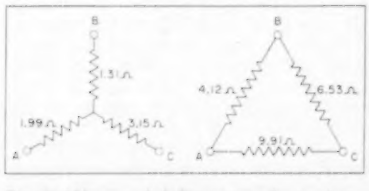


Fig. 2. Wye and delta networks equivalent to network illustrated in Fig. 1

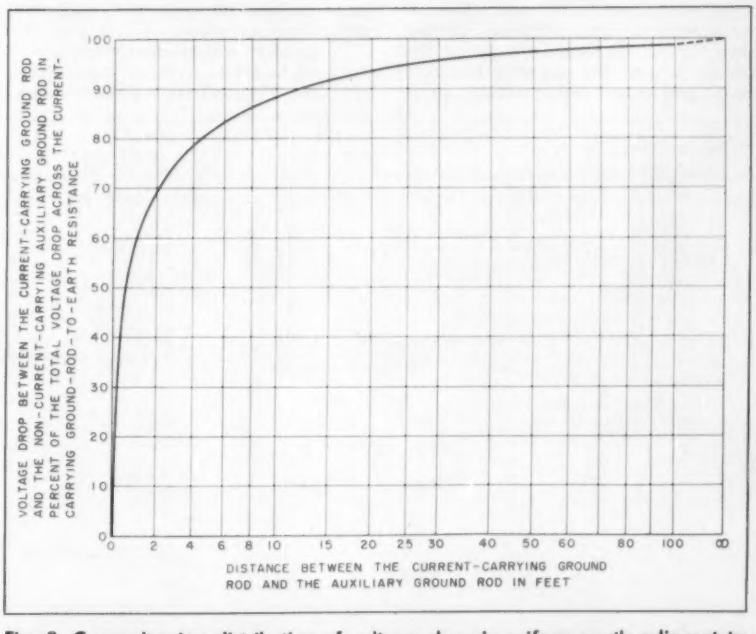


Fig. 3. Curve showing distribution of voltage drop in uniform earth adjacent to a current-carrying ground rod and a non-current-carrying auxiliary ground rod

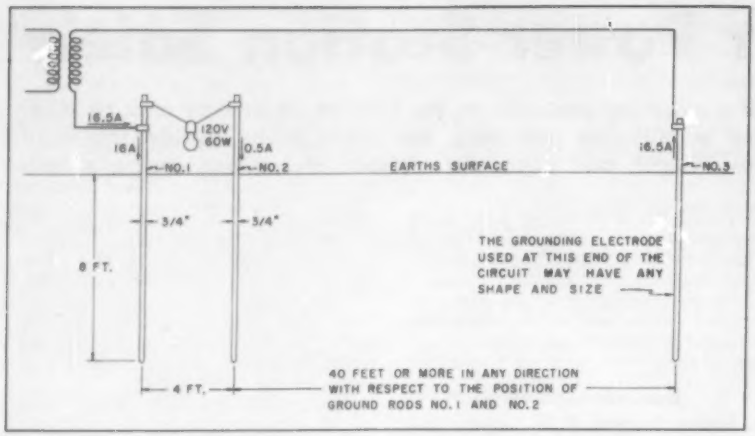


Fig. 4. Lighting a lamp between two ground rods. Values of current shown apply when each of the two has a resistance to earth of 10 ohms, and earth is uniform

the same between any two of them within 1.3 per cent.

Reason that the resistance would be very nearly the same between any two ground rods in this example is that in the earth circuit between them, about 45 per cent of the total resistance is near each end of the circuit. In other words, the effect of the resistance of the earth is relatively high where the current is concentrated.

If the resistance measured between the two rods which are 100 ft apart happened to be 20 ohms, a resistance of 9 ohms would be within a radius of 13 ft from each rod. Subtracting 2×9 from 20 leave only 2 ohms for the remaining portion of the circuit.

This part has a low resistance simply because its cross-sectional area is large compared with the effective cross-sectional area of the conducting path that exists near each end of the circuit where the current becomes more and more concentrated as it approaches one of the ground rods.

Figure 3 shows how the voltage drop in the earth between a current-carrying ground rod and a noncurrent-carrying auxiliary ground rod varies with the distance between these rods, where the earth is homogeneous and both rods have a depth of 8 ft and a diameter of ¾ in. This graph also indicates very closely the distribution of voltage on the surface of the earth surrounding a current-carrying ground rod where the earth is homogeneous and where the ground rod has a depth of 8 feet and a diameter of ¾ in.

This curve is based on measurements made with a tank containing a conducting fluid and submerged electrodes. The tank that was used for these measurements was specially made for the purpose, and had the shape of a hemisphere.

Tank and electrodes were constructed to scale, with 10 mm equal to 1 ft. The actual radius of the tank was 1 m, corresponding to a scale-value distance of 100 ft.

Figure 4 represents a transformer and a lamp connected to three ground rods. If these rods are separated by any distance that exceeds twice their depth in the earth it is a simple matter to find soil that will allow full voltage to appear across the 60-w, 120-v lamp shown with a source-to-ground current of not more than 30 amp.

The two rods to which the lamp is connected may be changed to any position with respect to ground rod No. 3 without causing an appreciable effect on the voltage across the lamp, providing the distance between ground rod No. 3 and ground rod No. 1 or 2 is at least five times the depth of ground rods No. 1 and 2.

This elementary circuit has been set up on two occasions for the purpose of demonstrating it. These demonstrations were made to illustrate how a fence at a substation could be dangerous for a person in contact with it while standing on the earth during a phase-to-ground fault on a line on the outside of the station, when the fault current is supplied by a grounded transformer secondary at the station.

In one case the fence and other metal structures were connected to the station-grounding electrodes and the station did not have a ground mat for the protection of personnel. Such a condition at a substation is illustrated by Fig. 5 which, as may be seen, is similar to Figure 4 as far as the circuit arrangement.

If the electrode-to-earth resistance of the station ground were made much lower than the value shown, then of course the voltage drop across it would be much lower also. This was the whole point in question concerning a particular substation when it was claimed, and rightly so, that the electrode-to-earth resistance of the station-grounding system was too

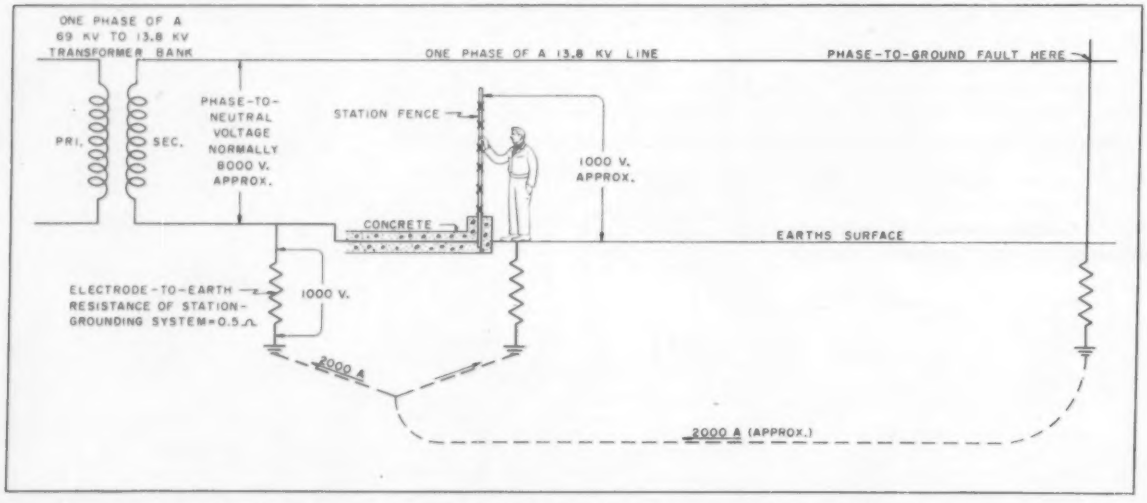


Fig. 5. Diagram illustrating how dangerous a station fence can be during a period when fault current flows to ground, in the case where the fence is connected to the station ground, and a ground mat is not used to protect against this hazard

high for safe operating conditions without the use of a suitable station ground mat.

Figure 6 is for the purpose of illustrating a hazard that may exist where a local water system is used as or connected to a substation ground. This diagram shows the use of an insulating link in the service entrance line. If this link were omitted, the voltage E_4 could reach a value on the order of 1000 volts or more during a fault-current period if the fault current supplied by the station to an outside phase-to-ground fault were high enough in relation to the resistance of the station grounding system.

Function of the insulating link is not primarily to place a high resistance between the water piping in the station area and the water piping outside the station boundary as might be suspected, but to introduce a resistance that will act as one element of a simple two-element resistance-type voltage-dividing circuit such as that shown by Fig. 7. However, an insulating link will not insure safe operation during a phase-to-ground fault unless care is taken to see that it is designed and installed so that it will reduce the voltage E_4 in Fig. 6 to a sufficiently low value.

Faucet shown in the station area is a hazard except where a ground mat is employed to eliminate the difference of potential that could otherwise exist between the faucet or any other grounded structure within the station area and the surface of the earth, during a period when a fault current is conducted to earth by the station grounding system.

Coupling

Figure 8 illustrates mutual-resistance coupling between two ground rods. This coupling exists to some extent between any two grounding elements that do not have a sufficient distance between them to cause the value of the coupling to be practically equal to zero.

Resistance values given in Fig. 8 are for two ground rods where each rod has a resistance to earth of 10 ohms. As may be seen, the mutual-resistance coupling is 22 per cent in this example. This value is based on actual measurements and is the per cent coupling that exists between any two ground rods in homogeneous earth that have a diameter of 0.75 in., a depth of 8 ft and a separation of 4 ft.

Such a set of conditions is seldom found in practice; however, this specific example does indicate the approximate percentage of coupling that can exist between two such ground rods in an actual installation. It is given here to illustrate, in conjunction with Fig. 9, the importance of maintaining sufficient distance between a power-station grounding system and other conductors in the earth such as an adjacent water pipe or a grounding electrode for a nearby communications system.

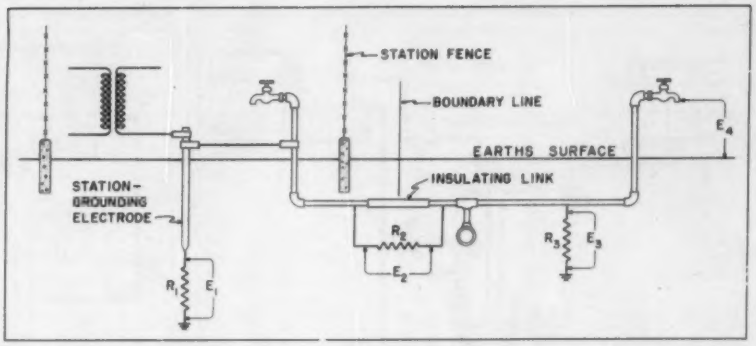


Fig. 6. Sketch showing the use of an insulating link to minimize a dangerous but not unusual hazard in which a high voltage may occur under fault conditions

Where two ground rods that have a depth of 8 ft are used as separate grounds for grounding a transformer station in a power system and a communications system, a distance between them of as much as 12 ft is, in some cases, not sufficient to prevent a dangerous potential appearing in the communications system during a period when a heavy current flows to ground from the power system.

In the event that a grounding system for a power station consists of several ground rods that have been driven to a depth of 30 ft or more, or where it consists of many ground rods that occupy a considerable area, a relatively large distance may be required between the boundary of the area covered by the ground rods and an adjacent water pipe or a ground for a communications system in order to insure safe operating conditions. The actual distance required will of course depend upon the geometry, use and resistance of the grounding system in question.

Surprising as it may seem, it is quite possible to light a lamp that is connected to two ground rods that have nothing but earth connecting them with a source of power. Fig. 9 illustrates how easily this can be done. It is the mutual resistance coupling that causes this. THE END

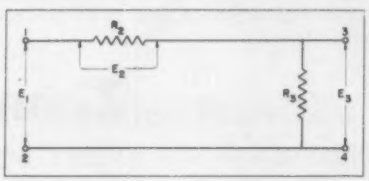


Fig. 7. A two-element resistance-type voltage-dividing network, like Fig. 6

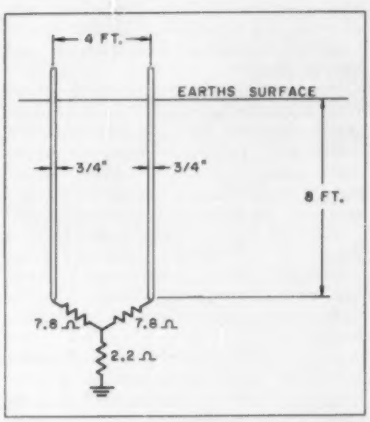


Fig. 8. Mutual-resistance coupling between two ground rods in uniform earth

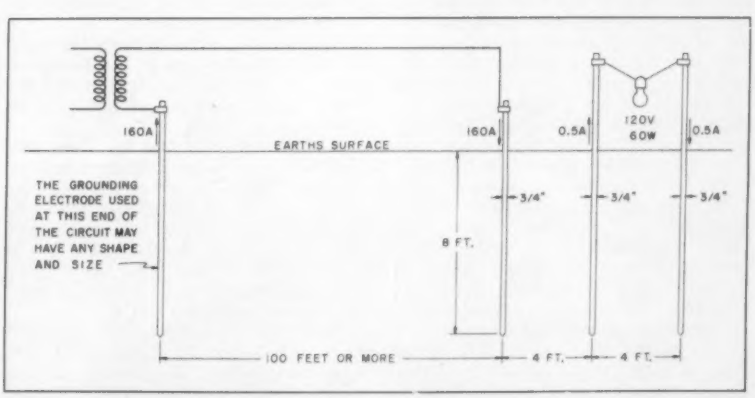


Fig. 9. Lighting a lamp having nothing but earth connecting supporting rods to power source. Each supporting rod has a resistance to uniform earth of 10 ohms

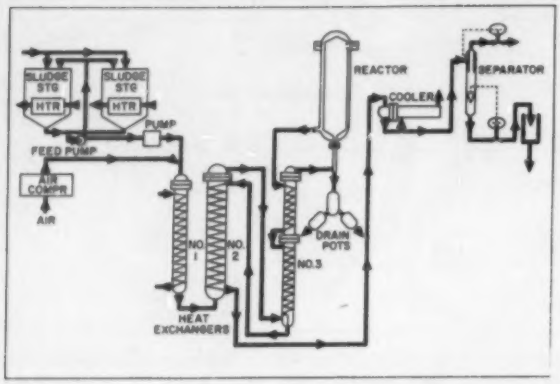
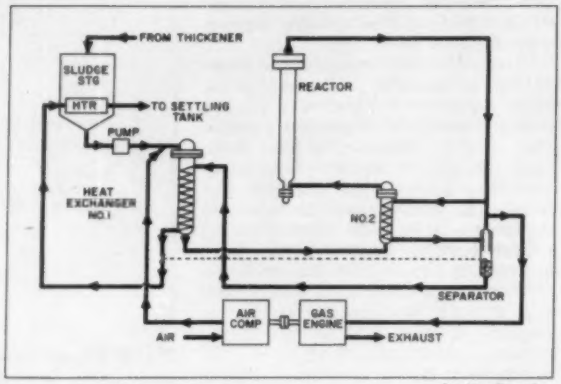


Fig. 1. Flow diagram for Zimmermann Process pilot plant which has operated since 1957 at Chicago Sanitary District



Sterling Drug Inc.

Fig. 2. Cost of installing a Zimmermann Process plant of 100 tons of sewage solids a day is estimated at $2,600,000

Zimmermann Process Works Well for Sewage Sludge Disposal

Sewage and waste disposal technique may be revolutionized by new simplified process tested by Sanitary District of Greater Chicago

THE CONTROVERSIAL Zimmermann Process has won acceptance by the Metropolitan Sanitary District of Greater Chicago as a practical method for disposal of sewage sludge.

Zimmermann Process pilot plant with daily capacity of 2 tons of sewage sludge was built at the District's Southwest Works and has been operating since September, 1957, treating primary sludge, activated sludge and varying combinations of the two.

Results have encouraged Sterling Drug, the Process's developer, to conclude that the Zimmermann Process will dispose of sewage sludge more economically than conventional methods.

In addition the Process requires less land area, less capital investment per ton of sludge, and has no odor or air pollution.

In a report just issued describing the Chicago test, Sterling Drug defines the Zimmermann Process as a radically new method of combustion which, in a continuous operation under pressure, oxidizes organic matter with air, while it is dissolved or suspended in water. The Process can achieve the same degree of combustion with water present as is achieved by first evaporating the water and then incinerating the dried residual.

When the Process is operating at 1200 psig, oxidizing sewage sludge that contains at least 6 per cent solids concentration, it will operate without using any outside heat or power except for starting. Since the Chicago pilot plant needed only 80 hp to operate, a power recovery unit was not installed. But where 300 hp or more is required to operate the Process, a recovery unit would be economically necessary. It might be either a mixed gas turbine or a piston expansion engine. (The Process would be thermally self-sustaining with a sewage sludge containing 3 per cent or more solids concentration.)

Pilot Plant

Schematic flow diagram of the Chicago pilot plant is shown in Fig. 1. As explained in the Sterling Drug report, various types of sludge are pumped to a settling tank located three floors below the Process plant. Here it is thickened by settling and pumped through a grinder so that particles no larger than ¼ in. are run into the Process storage tanks.

Sludge flows at the rate of approximately 200–240 gallons per hour from the heated storage tanks at 180 F through a rotary feed pump into a high pressure pump, and this high pressure pump forces the sludge up to the required pressure.

Immediately after passing through the high pressure pump, the sludge is joined by air from the air compressor, which has a capacity of 150 cfm at 1200 psig.

The sludge and the air then are passed through a preliminary heat exchanger (No. 1) to which steam is applied only during the start-up period, then through a second heat exchanger (No. 2), where the temperature is raised to 380 F, and finally to a third heat exchanger (No. 3) where the temperature is raised to 460 F.

The heat exchangers are designed to handle 4 gpm of sludge. The mixture then enters the bottom of the reactor and is oxidized as it passes upward through a coarsely baffled path in the central body of the reactor to where the resultant gases, water, etc, spill through a vent at the top of the inner shell into the space between that shell and the outside walls of the reactor.

Oxidation of the sludge is now completed, and the steam, nitrogen, carbon dioxide, water and other products, now approximately 515 F, pass through the bottom of the reactor into the No. 3 and No. 2 heat exchangers. As noted above, these heat exchangers help to preheat the incoming sludge and air.

In the No. 3 heat exchanger, the temperature of the oxidized material is reduced to about 500 F, and to about 440 F in the No. 2 heat exchanger. From there it passes through a water cooler, where it is cooled to about 150 F, and then into a separator.

Gases vent to the atmosphere and the effluent is withdrawn continuously from the separator. The ash, equal in weight to what would result from incineration of the same volume of solids, but more easily disposed of because it can be pumped to a lagoon or fill, is contained in the effluent. When lagooned or used as fill, it does not create obnoxious odors since it contains only about 10 per cent organic matter.

Main difficulty experienced at first was in obtaining a steady supply of homogeneous sludge to the storage tanks of the Process. But this difficulty was overcome, and runs in which the Process operated up to 16 days were successfully carried out. Recorded temperatures in equipment remained constant throughout.

Based on the experience with the Zimmermann Process at Chicago, Sterling Drug estimates that at today's prices the cost of installing a Zimmermann Process plant as shown in Fig. 2, to oxidize 100 tons of sewage solids per day, would be as follows:

Reactor	$220,000
Heat exchangers	240,000
Separators	3,500
Air compressor and motor	280,000
Air receiver	9,500
Expansion engine and reduction gear	290,000
High pressure sludge pump	80,000
Sludge storage tanks with heater	30,000
Building (approx. 70 by 140 ft)	100,000
Installation, engineering, construction, piping and instrumentation	1,347,000
Total	$2,600,000

Cost of operating the plant is estimated at about $120,000 a year, based on Chicago labor rates.

Or, assume a Zimmermann Process plant with capacity to treat 5.6 tons of solids (dry basis) per day received as primary sludge of 6 per cent solids concentration. To operate 365 days a year, such a plant would be approximately the size required by a city of about 110,000 population.

Sterling Drug estimates the cost of the installation as shown in this table.

Sterling's estimated operating cost of such a plant, without a power recovery unit, is approximately $30,000 per year. This assumes labor rates prevailing in Chicago during the pilot plant runs and power cost of 1 cent per kwh.

Without Power Recovery Unit:	
2 storage tanks	$10,000
2 pumps	14,000
2 heat exchangers	22,800
1 reactor	13,000
1 air receiver	1,100
1 air compressor & motor	31,110
1 separator	800
installation, engineering, construction, piping, instrumentation	187,200
Total	$280,000
With Power Recovery Unit:	
Power Unit—Cost and installation	$50,000
Total	$330,000

Estimated operating cost with a power recovery unit would be approximately $13,000 per year. This assumes labor rates prevailing in Chicago during the pilot plant runs.

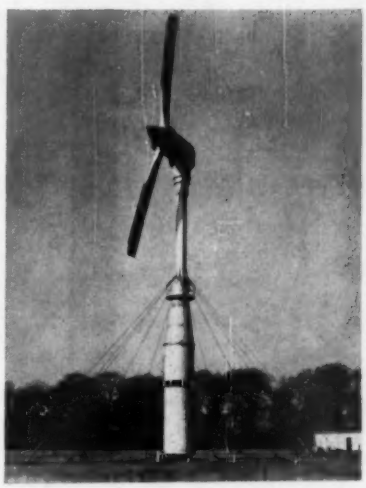
Largest Aircraft Propeller Provides Electricity in Algeria

BLENDING of aeronautical experience with a demand for electric power has produced a new type of power station. It is a 100-kw generating unit using a new principle.

Machine consists of a cable-supported tubular tower 100 ft high, at the head of which is mounted a two-bladed hollow rotor 80 ft in diameter, with an air exit near the top of each blade a few inches in from the trailing edge. Centrifugal force created by the rotation of the blades drives air out through the exits and, in consequence, air is drawn through an inlet near the base of the tower. Incoming air passes through a turbine which drives a generator.

Rotor revolves at 95 rpm over a wide range of 30–60 mph, and the turbine rotates at 1000 rpm, at which speed the generator develops its output of 100 kw. If the wind speed exceeds 60 mph, the blades are automatically feathered.

Air-tight seals are fitted between the circular root ends of the blades and the spinner, and the spinner, in turn, is sealed to the hub by a face-type labyrinth. All the joints in the tower structure are air tight and there is, in effect, a continuous duct from the inlet situated near the base of the tower to the air exits at the blade tips.



Wind-driven generator under test at St. Albans, Herts, England. It's putting 100 kw into Algerian electricity

This method of coupling windmill and generator without a mechanical link was invented by a French engineer, J. Andreau. The British Central Electricity Authority decided to adopt the idea. Experiments by the de Havilland Propeller Co brought out many improvements on the original Andreau idea and the new power station was proposed for Mynydd Anelog, a Welsh mountain, where severe wind conditions prevail. Unexpected local opposition, however, vetoed the proposal on amenity grounds and the CEA was left with it on their hands.

The windmill-generator has now been handed over to the Electricité et Gaz d'Algerie and has been erected on a wind-swept spur of the Atlas Mountains six miles west of the city of Algiers and 870 ft above sea level. The Algerian company is reported to be very pleased with their new acquisition.

P.A.T. Machine Can Produce Speech

WHO'S PAT? Pat is the nickname given to the British Ministry of Supply's talking machine which has been designed for research work on the nature of human speech. This unusual machine not only can create all the sounds that are normally used in speaking, but can string them together to produce the illusion of complete words and phrases. It can, in fact, talk.

The initials P.A.T. stand for "parametric artificial talker." The sounds produced by the device are controlled by parameters, or signals. These vary the quality of the sound from moment to moment, in the same degree as the sounds coming from the mouth of a human speaker are varied by the action of his tongue and vocal chords. In place of the vocal chords, PAT has an electron tube oscillator, and electrical resonators serve as tongue and lips.

The machine was built to test a hypothesis about the nature of speech sounds and their perception, and so point the way to greater economy in the use of telephone cables. The fact that PAT's speech is intelligible proves that speech can be specified by signals which change value quite slowly and hence can be sent over very narrow bandwidth signalling channels. This may lead to a marked reduction in the bandwidth required for a telephone conversation, enabling 20 to 30 times as many simultaneous conversations to be carried on long-distance telephone links.

Maintaining Centrifugal Pump Shafts and Sleeves

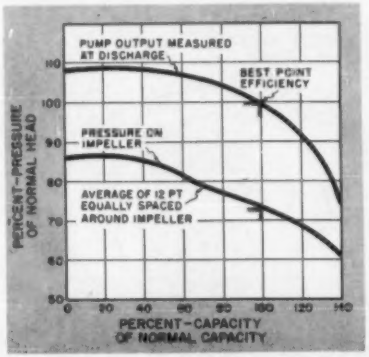
By J. A. CABLE* and O. M. KRISTY*

PUMP SHAFT should be designed for ample strength and service life. Proper machining of fillets, keyways and threads will safeguard against physical failure if the following conditions are observed at the time the pump is selected: 1. corrosive nature of fluid being pumped; 2. operation range of pump with respect to best point of efficiency; 3. alignment of pump and drive.

Corrosive nature of the fluid being pumped is probably the largest single reason for pump shaft failure. The addition of corrosive activity to a shaft undergoing normal fatigue will cause failure in a comparatively short time. In other words, corrosive fluids will rapidly shorten the normal operating life of a shaft made of a material not resistant to that fluid. This normally causes fracture at the point of maximum physical stress of the shaft.

There are five basic shaft materials used in centrifugal pumps. Table I will act as a guide to their selection with respect to typical fluids. This should be used only as a guide. It is best to get recommendations for specific applications.

The second most important item in preventing shaft failure is job operation range with respect to best point of efficiency of the pump's curve. On either side of the best point, pressures around the impeller are not equal but impose variable radial thrusts. The graph shows a typical curve to demonstrate this effect.



On either side of best point of efficiency, pressures around impeller are not equal but variable

Of course, a good volute design will decrease this effect, and double volute design will further minimize the unbalanced thrust.

If a pump must operate at capacities other than in the range of its best point of efficiency, something less than a maximum diameter impeller should be used. For a guide, about 0.9 of the maximum diameter of the largest impeller which can be used, will cover most conditions. Therefore, for maximum shaft life select your centrifugal pump to operate at or near the best point of efficiency.

Third most frequent reason for shaft failure is pump and driver misalignment. In this discussion we will simply say that coupling alignment — under operating conditions — must be maintained.

There is no substitute for "good" alignment in getting maximum shaft, bearing, and coupling life. Poor alignment will affect any or all of these items to a point of absolute failure.

Good alignment is maintained with driven, and driving machine operating on the same center line, with no angularity between them. Permissible tolerance of 0.001 in. to 0.0045 in. maximum will assure long, trouble-free years of service to these parts.

* Application engineer and supervisory engineer, respectively, Centrifugal Pump Dept, Allis-Chalmers Mfg Co

Table I. This serves as guide to basic shaft materials used in centrifugal pumps. While other materials are also used, these are the most popular for total range of fluids handled by these pumps

	Copper Base Alloys	Monel	SAE 1045 Carb. Steel	Type 420 St. St.	Type 316 St. St.
Caustic Alkalies	3	1	3	4	4 & 5
Sulfuric Acid	3	1½	4	4	3
Halides	3	2	4	4	4 & 5
Alkaline Salts	3	1	4	4	3
Neutral Salts	2	1	4	4	2
Organic Acids	3	3	4	3	1
Acid Salts	3	3	4	4	2
Ammonia Solutions	4 & 5	4	3	2	1
Oxidizing Acids	4	4	4	3	1

LEGEND:
1. Excellent resistance
2. Good resistance
3. Fair resistance
4. Poor resistance
5. Susceptible to pitting or stress corrosion

Table II. Hardness of typical shaft sleeve materials, and guide to relative cost comparison

	Brinell Hardness	Cost* Basis
Aluminum Bronze	180	100%
Type 420	500	180%
Type 316	180	210%
"S" Monel	350	315%
Stellite on Type 316 St. St.	600	625%

*Aluminum Bronze is the base or 100%.

Shaft Sleeves

Shaft sleeves have but one purpose and that is to protect the shaft from packing wear. Therefore, all factors governing the selection of a shaft concern the sleeves, plus problems directly connected with the packing.

There are three principal things to consider concerning shaft sleeve material: corrosion, hardness, and cost.

Obviously the best sleeve for the job is the one that combines maximum service life with minimum cost.

For guidance in choosing the proper material for the job with respect to corrosive activity of the fluid being pumped, again consult Table I. Here can be found a material that will not be readily attacked by the fluid.

Next, decide whether the hardness obtainable from this material is satisfactory for your job. The considerations are: suction pressure, suction temperature, and suspended solids in fluid.

Recommendations of sleeve material and packing were given in the first chapter of this series (October issue). However, Table II shown here is a guide to hardness of typical shaft sleeve materials, and gives a relative cost comparison.

Cost of a shaft sleeve can vary greatly depending upon its ability to resist corrosion, and the hardness of its surface. However, balanced against this initial cost should be considered service life, the amount of allowable down-time for replacements and the expense of making the replacement, as well as the loss of revenue from not having this machine in service.

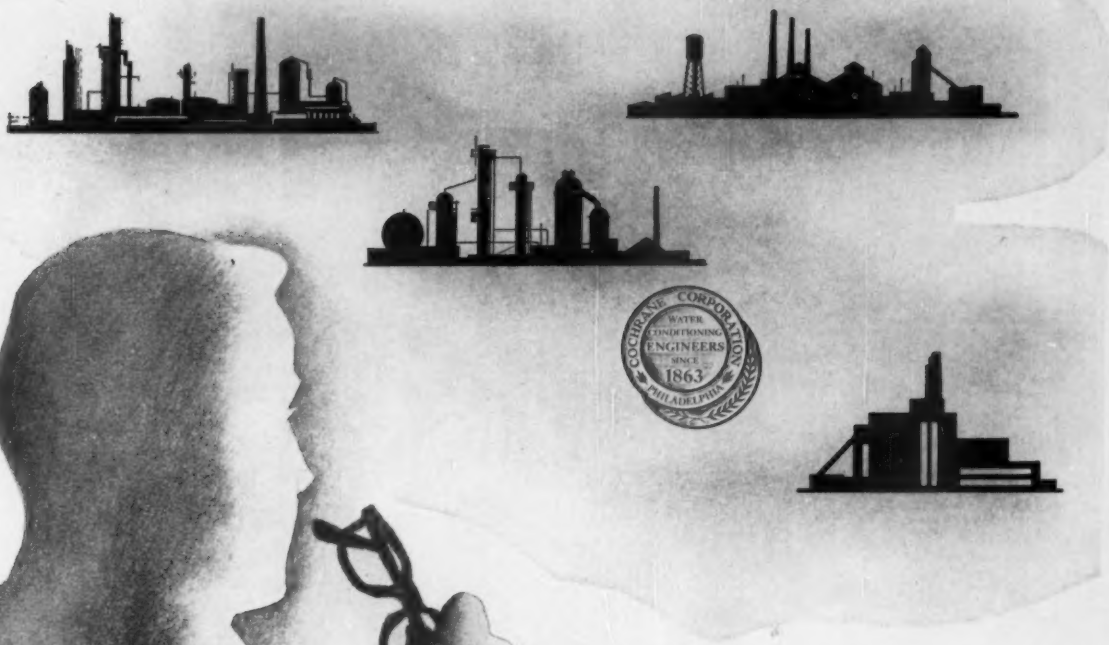
Careful estimation of the above costs may well be surprising in that the most expensive shaft sleeve initially may well be justified by these other expenditures.

It goes almost without saying that a properly packed stuffing box is a trouble-free stuffing box. The mechanics of packing a stuffing box call for a clean box with a smooth concentric sleeve (maximum concentricity tolerance of 0.003 in. total indicator). Along with selecting the proper shaft sleeve, considerable thought should be given to the

fold along this line—outside edges toward you

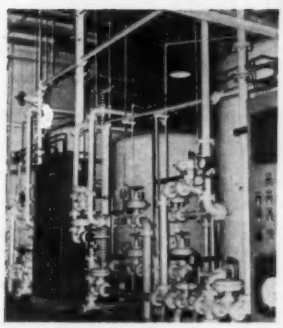
POWER ENGINEERING HANDBOOK

Progress in water conditioning . . .



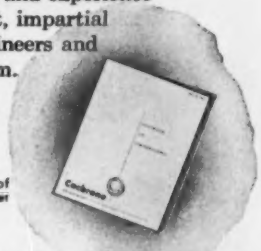
Will it pay you to DEMINERALIZE *your boiler feedwater?*

There is no simple answer to that question. From the standpoint of water quality, the superiority of demineralization is unquestioned. It removes dissolved solids, including silica more completely than any other treatment method and is a "must" for high pressure boiler systems. But in some cases the installation and operating cost of a demineralizing system may not be economically justified. Instead, another type water treating system may be advisable, particularly for boilers in the medium pressure range of 750 to 1250 psig.



As we said, there is no simple answer. But there *is* an easy way to find the answer: Present your problem to Cochrane water treatment specialists. They have designed water treatment systems for industrial plants and utilities with makeup feedwater requirements as high as 8000 gallons per minute! This background and experience in all phases of the art is your guarantee of an expert, impartial analysis and recommendation because, Cochrane engineers and manufactures every type of water conditioning system.

To find out whether or not demineralization is the answer to your feedwater treatment problem write: Water Treatment Division.



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packing job required. Refer to the first chapter of this series (October 1958 issue, POWER ENGINEERING, Handbook section) and to your local packing representative, to get the best packing for the job.

Naturally, any abrasive material in your pumped fluid will get into the packing and rapidly grind the sleeve. Therefore, when pumping dirty or gritty fluids, these are essential for good sleeve life: an outside seal of solid-free, neutral water to provide a packing lubricant; a vacuum sealer; and stuffing box flush at a pressure greater than the pressure imposed on the stuffing box.

Generally, considerable thought is given to the seal around the outside of the shaft sleeve. Yet there also is need for a seal under the shaft sleeve to prevent leakage along the shaft.

These seals may be located either at the joint of the shaft sleeve and impeller hub or at the joint of shaft nut, and shaft sleeve.

The seal itself may be a plastic or fibre flat gasket, such as used between impeller hub and shaft sleeve; or it may be "boot cord" or string packing such as is used in the double chamfer between shaft sleeve and shaft nut.

A third and more recent type of seal that is simple to install and positive in its sealing ability, is the "O" ring. This may be located in a counterbore adjacent to the shaft nut, or in a groove in the face of the shaft sleeve at the impeller hub end, or in both locations. New pump designs have standardized on the use of the "O" ring because of ease of maintenance, its low cost, and wide range of pressures, temperatures, and fluids handled.

So the approach to satisfactory pump operation with the minimum of maintenance must include the choice of the best shaft and shaft sleeve material for the job. Then, with proper packing selection, installation and maintenance, your reward will be trouble-free service.

This article is third in a continuing series on proper maintenance procedures for centrifugal pumps. Discussed so far: stuffing boxes fitted with packing, and stuffing boxes with mechanical seals

Testing and Calibration of Circuit Breakers

CIRCUIT BREAKERS and their auxiliary relays play a vital part in the protection of any electrical distribution system. The modern low voltage circuit breaker normally incorporates a series trip device with both instantaneous and time delay features. In some breakers the time delay trip is adjustable both in pickup valve and time delay, whereas the instantaneous feature is adjustable only in pickup value.

As explained in the *Accident Prevention Bulletin* of Mutual Boiler and Machinery Insurance Co:

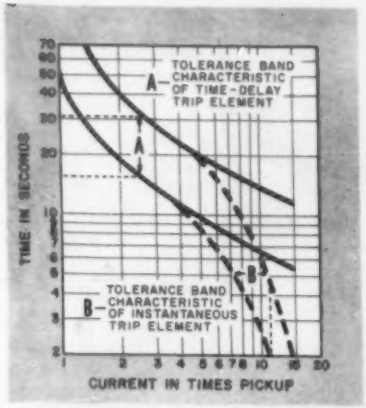
It might be assumed that the series trip device of both the time and instantaneous elements was calibrated to pickup precisely in accordance with the setting shown on the adjustable scale, but such is not the case. It should be pointed out that the pickup setting of the smaller breakers, which is that level of current at which the trip element starts to operate, has a plus or minus 10 per cent tolerance, NEMA standards.

In the larger breakers the pickup tolerance can be even greater — ranging from +20 per cent to −32 per cent. This tolerance band allows for variations in performance between successive operations of one particular device, but primarily it is to allow for variations between devices due to manufacturing tolerances. Each breaker will have a relatively narrow tripping-time band which will lie somewhere within the over-all allowed tolerance band.

The distance between the two solid lines in the figure, shown as A, represents the latitude allowed in the operation of the time-delay trip device. For example, at 2.5 times pickup current the particular breaker should open between a time interval of 15.5 to 31 seconds. This tolerance would be very important if the circuit breaker were protecting critical equipment.

The distance between the dashed lines

—fold along this line—outside edges toward you—



For example, at 11.2 times pickup current, the particular breaker should open in 2 to 5 seconds

of the figure represents the latitude allowed in the operation of the instantaneous trip device. For example, at 11.2 times pickup current, the particular breaker should open in a time interval of from 2 to 5 seconds. With an intermittent arcing fault this tolerance could make the difference as to whether or not the breaker would open to protect the equipment at fault from complete destruction.

Series Trip Test Equipment

To assure adequate protection it is desirable to check the tripping characteristic of circuit breakers rather than to simply assume that the breaker's setting is satisfactory.

It is a relatively simple matter to determine the minimum operating current and one point on the time-current curve of the time-delay element of a series trip device with a rating up to 400 amp. This would require a 1-kva low voltage transformer having an adjustable secondary from 0–500 amp at 0–2 v.

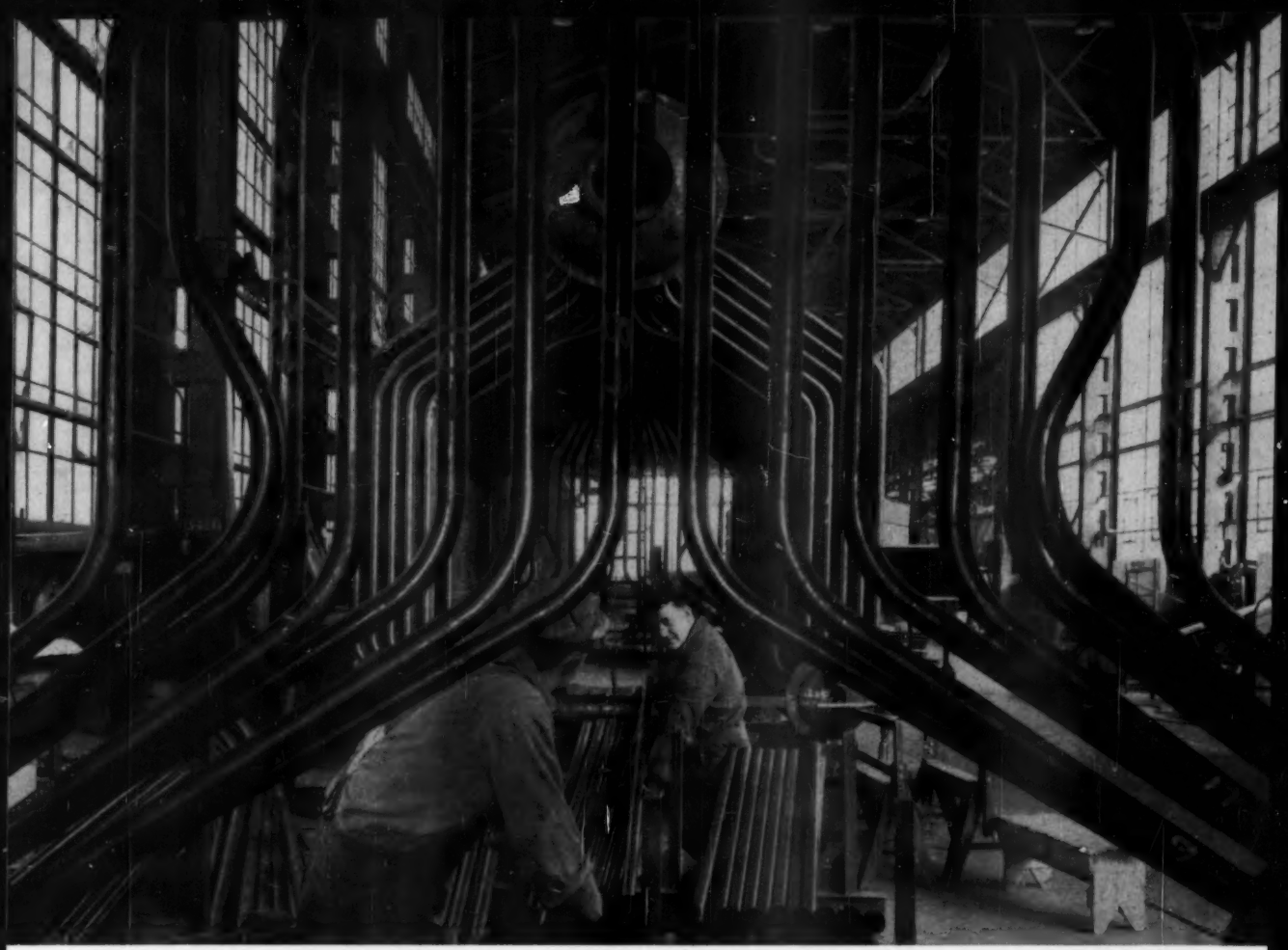
To check the time-current characteristics of a series trip device rated above 400 amp or the "go" — "no go" limits of the instantaneous trip element requires larger test equipment of the caliber not ordinarily found in the average plant maintenance shop. There are several instruments on the market for the testing and calibrating of current actuated protective devices.

In smaller plants, where the maintenance department cannot justify the purchase of a test instrument, arrangements may be made for the Engineering Department of Mutual Boiler and Machinery Insurance Co. in Waltham, Mass., to provide circuit breaker testing service on a fee basis. Maximum protection demands accurate calibration of the tripping device of all main distribution circuit breakers.

Standard models of the Multi-Amp test equipment used by Mutual Boiler, ranging in size from 2.5 kva to 25 kva, are applicable on General Electric type AK 1–50, Westinghouse DB-50, ITE-type KC and Federal Pacific Electric type DMB-5 circuit breakers of the continuous current ratings shown in the table.

Standard Multi-Amp test equipment is applicable on circuit breakers of these continuous current ratings

Circuit Breaker	Multi-Amp Model Number Required to Obtain				
Continuous Current Rating	200% Overload	300% Overload	400% Overload	500% Overload	1000% Overload (Instantaneous)
200–225–250–275–300	2025	2025	2025	2050	2050
325–350	2025	2025	2050	2050	2075
400–450	2025	2025	2050	2050/2	2075
500–600	2025	2025	2050	2050/2	2075
800–1000	2050	2075	2075	2075	2150
1200	2050/2	2075	2075	2150	2150
1600	2050/2	2075	2150	2150	2150



J&L welded boiler tubing is being used by Wickes Boiler Co. for a wide variety of products, including these boiler pressure assemblies.

"We can rely on J&L welded boiler tubes to have uniformly sound physical properties"

"They meet all of our rigid production and quality control requirements," says Wickes Boiler Company official

The Wickes Boiler Company of Saginaw, Mich., a division of the Wickes Corp., has found J&L electric-resistance-welded pressure tubing to be well adapted to its needs, reports D. H. Barnes, division president. J&L boiler tubing has been used in a wide variety of Wickes products, including the newest Wickes Type-A water tube steam generator, the largest shop assembled generator of its type ever built. This generator is now in use in a large steel plant.

Wickes has custom-designed and built boilers—featuring J&L pressure tubing—for a variety of installations, including hospitals and chemical refineries, schools and automotive plants, military posts and food processors.

If your firm makes a product involving pressure tubing, investigate J&L's service-proven steel tubing. J&L pressure tubing has been used for closed-type feedwater heaters, industrial hot water heaters, cooling water heat exchangers, and package steam generators, to mention only a few applications.

For more information, call your J&L representative. Or write to Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30, Pa.

Uniformly sound physical properties in J&L welded boiler tubing eliminate bending problems and assure trouble-free assembly of tubular components.

The exciting new J&L

Jones & Laughlin Steel Corporation

PITTSBURGH, PENNSYLVANIA

J&L STEEL

For more data circle 533 on Post Card

EQUIPMENT NEWS

Described on these pages are new and improved products. Use Reader Service Cards on pages 105–106 to ask for more information on them. Just circle the item numbers of all the products in which you are interested.

1—FUEL OIL TREATMENT with soot removal benefits

Formula C-8 is announced as combining a fuel oil treatment with a soot remover. It is a blend of organic solvents for sludge dispersion, an emulsifying agent to handle water contamination in storage tanks, and a material to lower the ignition point of soot on boiler heating surfaces. This is said to permit soot to be readily ignited at normal furnace temperatures. The formulation is fed at the rate of 1 quart to each 1200 gal of fuel oil in the system. Where heavy sludge deposits exist, the rate may be stepped up. Formula C-8 is fed into fuel oil storage tanks just before delivery of fuel oil, to assure adequate mixing throughout the tank. The Bird-Archer Co.

2—TUBE EXPANDER DRIVES for heat exchangers, boilers

Two air-driven heavy duty models have been added to the Torq-Air-Matic line of automatic tube expander drives. Model B (shown) is available in three versions, from 38 to 22 ft-lb torque and from 450 to 750 rpm, and is designed for

heat exchangers used in oil refineries, chemical plants, and other processing operations, and may be used with ferrous or non-ferrous tubes up to 1½ in. OD. Model C, 75 ft-lb torque and 200 rpm, is for tubes used in package or power plant boilers, re-boiler or waste heat boilers, ammonia condensers, sulphite evaporators, air-preheaters. It will roll up to 3 in. in ⅝-in. sheet. Like the original Torq-Air-Matic model, these drives measure torque output directly at the mandrel by mechanical device, without use of frictional, ratcheting, magnetic, hydraulic or electrical devices. Thomas C. Wilson, Inc.

3—WEAR-IN COMPOUND offers performance advantages

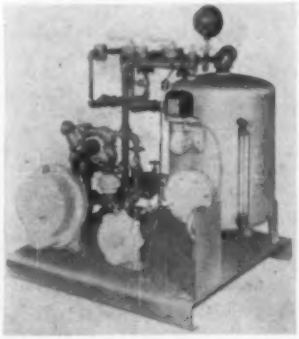
Molykote Wear-In Compound, a molybdenum disulfide compound, is announced as offering advantages in the reduction of damage during "wearing in" of new machinery. According to manufacturer, this compound shortens the "wear in" period without use of abrasives; reduces galling, seizing and excessive wear during this period; safeguards against expense associated with disassembly, repair and replacement of damaged parts; need not be burnished into the surface; is inexpensive — a little goes a long way. The Alpha-Molykote Corp.

4—HEAT RESISTANT PAINT for those hot metal surfaces

Heat-Rem H-170 is announced as an extra-high heat resistant paint that makes possible coating of many surfaces, formerly regarded as "unpaintable" due to temperature limitations. The paint is said to withstand temperatures to 1700 F. It is reputed to virtually fuse with hot surfaces to form a continuous, uniform, attractive coating. Made of heat-resistant aluminum, combining both "leafing" and "non-leafing" characteristics, and colored metallic pigments in a silicone base, Heat-Rem H-170 is claimed to air dry in 30 min. As a result it can also be used to protect surfaces in the lower temperature ranges, from 200 deg upward. Paint is offered in four standard colors — aluminum, metallic blue, metallic red and gold. It is claimed ideal for manifolds, heat and steam lines, ovens, furnaces, condensers, compressors, boilers and stacks. Speco, Inc.

5—BLOWDOWN SYSTEM is manually controlled unit

The Basic Boiler Blowdown and Sampling System is offered for boiler rooms where the fully automatic operation, complete instrumentation and cabinet design of this manufacturer's Packaged Console Continuous Blowdown Recovery System may not be desired. It sells



for about half the price of the latter and incorporates similar components — volume control valve, strainers with drain manifold, insulated flash tank with drainer, high level alarm, safety valve, sample cooler, main heat exchanger and sight flow indicators. It is a packaged system designed to provide all functions of continuous blowdown, but under manual control. It does not include cabinet or sampling sink and has less instrumentation than the automatic system. It can be made to accommodate from one to four blowdown stations with capacity to 5000 lb of blowdown per hour, for 250 or 600 lb maximum working pressure. The Fred H. Schaub Engineering Co.

6—OIL RECLAIMER with central control panel

Hilco Hyflow Oil Reclaimer Model 300-X is designed for full-flow purification of lubricating and sealing oil in 28 high vacuum pumps, with a total oil circulating rate of 224 gph. The system, fabricated in two sections, consists of inlet

and outlet oil pumps, vacuum pumps, electrically heated vacuum vaporizer, distillate tank and duplex fullers earth filters. Features stressed include the centrally located graphic control panel. The panel controls operate pumps and indicate heater operation, solenoid positions, tank levels and flow characteristics. From this panel are operated duplicate sets of inlet and outlet pumps and vacuum pumps, a set of each being used as stand-by units. Also utilized in conjunction with distillate collection is an automatic draining distillate tank. Automatic recirculating features on the vacuum vaporizer serve to permit dry oil (water less than 10 ppm) to be pumped from reclaimer to vacuum pump delivery system. The Hilliard Corp.

7—GREASE resists most liquid fuels and solvents

According to manufacturer, this grease permits normal lubrication of pumps, bearings and sliding surfaces that must work in the presence of solvents and liquid fuels. It is claimed resistant to most fuels and solvents and impervious to the washing action of a wide range of petroleum, coal tar and chlorinated liquids. Pennsylvania Refining Co.

8—ANALOG COMPUTER is lower in price, easier to use

Belac is a load distribution analog computer designed to provide instant, visual interpretation of operating data in utility power systems; it is said to cost up to 50 per cent less than conventional apparatus performing the same function. Housed in a compact and portable cabinet convenient for desk-top use, it is operated by manipulation of dials — load slide rules and consultation of charts, graphs and curves are not required. According to manufacturer, this economy analog computer is adaptable for custom programming and helps reduce fuel and maintenance costs by furnishing information on most efficient load distribution among many generators at any given time.

Information fed to the computer by manual adjustment of control knobs in-

Refinery Power Plant Compares Bonnet Joints

No maintenance for Crane Pressure-Seal valve on 10-year high-pressure/high-temperature service

Ten years ago two 10-inch, high-pressure-temperature gate valves were installed in the power plant of a Midwest refiner. Each one was installed on a boiler lead line, where steam service is 900° F. at 1280 psi.

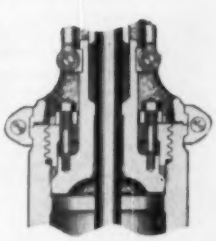
One valve is a conventional bolted bonnet type; the other, a Crane Pressure-Seal Bonnet Valve.

The bolted bonnet valve has required major maintenance four times in ten years because of bonnet joint leakage.

The Crane Pressure-Seal Bonnet Valve, during the same period, has never leaked . . . has needed no maintenance of any kind!

Conventional valves fight line pressure with heavy flanges and bolts at the bonnet joint. The bolting requires restressing and maintenance with each extreme change in temperature. Crane Pressure-Seal design harnesses line pressure to keep the bonnet joint tight despite extreme variations in temperature and pressure.

For complete information about Crane Pressure-Seal Bonnet Joint Valves—gates, globes, angles, stop-checks and swing-checks—in 600, 900, and 1500-pound classes—call your Crane Representative, or write to address below for new Circular AD-2336.



Here's the Crane Pressure-Seal Joint that eliminates bonnet joint leakage and maintenance on high-pressure-temperature services.

CRANE VALVES & FITTINGS

PIPE • PLUMBING • KITCHENS • HEATING • AIR CONDITIONING

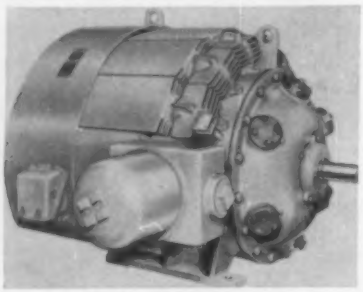
Since 1855—Crane Co., General Offices: Chicago 5, Ill.—Branches and Wholesalers Serving All Areas

For more data circle 534 on Post Card

cludes fuel cost, maximum and minimum capabilities of individual generators in a system, base load generation, interchange sales and system total. Provision is also made for future insertion of effect of line losses on economy loading computations. All system conditions are continuously variable over the entire range, it is noted, and any given machine can be switched into or out of computation at will. Among factors dealt with are turbine back pressure, spinning reserve data, cooling water temperature limitation, effects of hydrogenation, changes in fuel costs and tie-in line sales. The computer operates on 115 v, single phase, 60-cycle power. Belock Instrument Corp.

9—HEAT EXCHANGER MOTOR in 25- to 300-hp ratings

Designed to provide a wide adjustable speed range, this d-c motor is also intended for constant speed applications and comes in ratings from 25 to 300 hp. It is available in an explosion-proof enclosure (Class I Group D) for hazardous installations and with standard enclosed construction for protection



against abrasive airborne particles, dirt, coolants, moisture, oil vapors and other severe atmospheric conditions. It is suggested for indoor or unprotected outdoor service in the oil and chemical, cement, paper, rubber and steel industries, and for machine tool and material handling applications.

Range of adjustable speed offered extends from 5 per cent of base motor speed by armature control (constant torque) to 400 per cent of base motor speed by field control (constant horsepower). A factor in broadening this adjustable speed range and minimizing motor size is use of an integrally mounted a-c fan motor to supply a constant flow of cooling air regardless of speed of the d-c motor. Heat exchanger tubes of heavy-section, aluminum alloy are distributed around the periphery of the field ring. The motor can be mounted floor horizontal, wall or ceiling horizontal, or vertical with shaft up or down. Bulletin 3000 gives more data. The Louis Allis Co.

10—AIR VIBRATOR for precipitators, dust collectors

Designed to reduce maintenance problems associated with electrostatic precipitators and dust collectors, the Navco BH-3-SP Hi-Impact Vibrator is a heavy-duty unit of one-piece construction. According to manufacturer, there are no body assembly bolts and the piston is the only moving part. The vibrator can be arranged with timer and solenoid valve for automatic control. It weighs 52 lb, is 11 in. long, 5 in. wide and 10½ in. high. National Air Vibrator Co.

11—DISTRIBUTION SYSTEM has simplified supporting spacer

The Trimline is a primary overhead distribution system featuring a Plexiglas supporting spacer, extruded high molecular weight polyethylene insulated phase conductors, and high strength supporting messenger. It is intended for utility and industrial distribution circuits from 5 to 15 kv and is reported to offer several advantages over open-wire construction. The supporting messenger provides storm damage protection, it is noted, and eliminates need for additional crossarms. It is claimed simple to install, splice and terminate. Longer spans are possible as system weight permits spans to 300 ft without overloading the pole, according to manufacturer, and better voltage regulation is possible due to lower reactance.

It is pointed out that the one-piece Plexiglas spacer has no mating or matching surfaces to create crevices which might collect water or contaminating substances and this reduces possibility of eventual arcing or shorting. Each spacer has four snap-lock Neoprene grommets. Built-in compression rings in these grommets serve to provide a snug

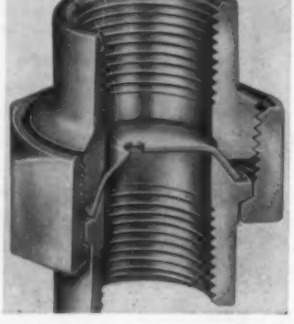
spacer-to-cable fit, and constant pressure exerted upon the messenger and conductors restricts the spacer from sliding. A single size spacer is used for voltages to 15 kv, made possible because of a 6-in. spacing between phase conductors and interchangeability of Neoprene grommets. Grommets of different sizes are availbale to accommodate various phase conductor and messenger diameters to 15 kv. Rome Cable Corp.

12—COMPRESSORS, single-stage, centrifugal units

For refinery and petrochemical applications, this line of centrifugal compressors includes Type OM, for providing air service at low discharge pressures and Type OPB for handling gas and air applications at higher discharge pressures. Sizes cover the 1200 to 80,000 cfm range with input horsepowers from 10 to 2500 bhp. Discharge pressures to 900 psig can be handled in the lower capacity models. Of simple design, these single-stage centrifugals are essentially constant pressure, variable volume machines. They can be used for blower service where inlet conditions are atmospheric; for exhauster service where inlet conditions are below atmospheric pressure; or booster service where inlet conditions are above atmospheric pressure. Details are given in Bulletin 165. Clark Bros. Co.

13—ORIFICE UNIONS require no separate gaskets

This union features a cup-shaped stainless steel orifice plate which fits into place between conventional pipe union



head and tail pieces to form a tight seal with ground joint steel to stainless steel seats. Separate gaskets are not used. The cup-orifice unions are made in ⅛- to 2-in. pipe sizes, with 3000 psi pressure rating. Catawissa Valve & Fittings Co.

14—SELF-STICKING LABEL can be used outdoors

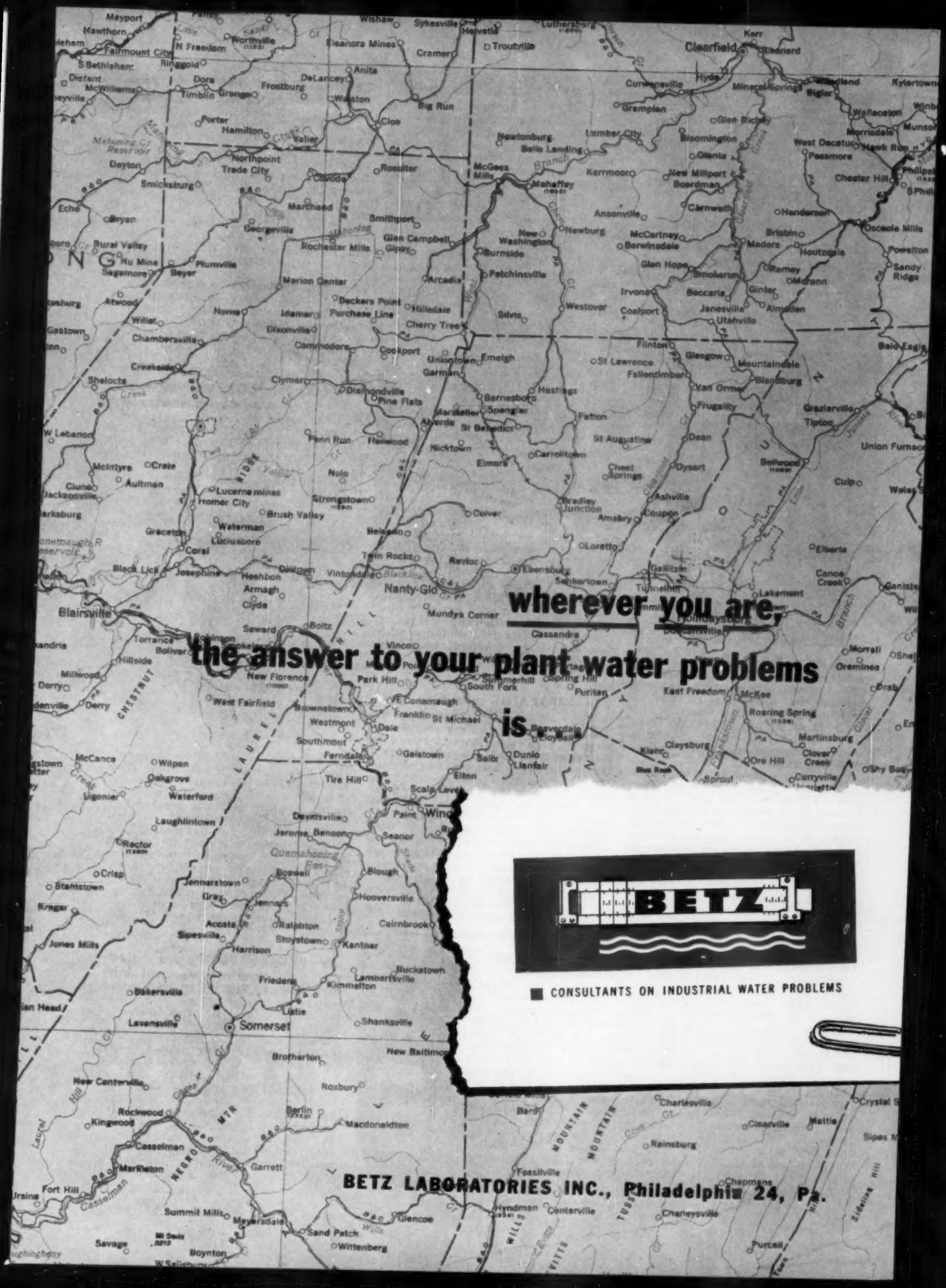
For outdoor or permanent indoor use, the MC Labelon consists of a pressure-sensitive card that can be written or typed on, then covered with an attached clear layer of outdoor-type Mylar plastic for protection. The Mylar cover withstands rain, dirt and sunlight, it is pointed out, and is not affected by grease, oil or acids. The labels are reported to resist heat up to 300 F, cold to −100 F. Labels are available with borders in black, blue, red or green and come in small tray-type boxes. Sizes range from ⅝-by-1½ to 2-by-3¼ in., the smallest labels costing only a cent apiece. Labelon Tape Co., Inc.

15—THREAD COMPOUND for high temperature service

Now based on a new formula, this manufacturer's anti-seize thread compound for high temperature service is said to retain its homogenized consistency indefinitely, and to be non-settling, non-skinning, and non-hardening in the can. Effective lubricating and anti-seize properties at temperatures to 1050 F are announced. The compound is highly adherent, will not run or drip from vertical joints or under high heat exposure, it is claimed; also it will not harden, shrink or crumble on application, it stays flexible inside of joints, and has no deteriorating effect on piping materials. It can be used on threaded pipe joints, bolt studs and for coating gaskets for service under high temperature and high loading. Crane Co.

16—SAFETY LADDER of strong, reinforced plastic

According to manufacturer, this ladder is fire-resistant, extra strong and almost indestructible, and every known safety feature has been incorporated in its design. It is constructed of Hetron polyester resin reinforced with fiberglass, and features a method of locking in the rungs which precludes their loosening or pulling away from the siderails. It is also said to contain no materials that conduct electricity. The rungs are rough surfaced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the answer to your plant water problems
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BETZ LABORATORIES INC., Philadelphia 24, Pa.

to prevent slipping and siderails are non-splintering and designed for easy gripping. This plastic ladder is described as inherently impervious to exposure, rot and corrosion, warping, and moisture absorption. Company says it is unaffected by boring insects and under normal conditions should last indefinitely, even when stored outdoors. American Allsafe Co.

17—SIX-POLE ANODE BREAKER with single pole drawout

This metal-enclosed six-pole anode circuit breaker, Type FB, is designed to permit drawout of individual poles without interruption of process power. The single-pole drawout, providing continued supply of d-c power while one phase is being serviced, is suggested for processes where high-speed anode breakers are used for fault protection of mercury arc rectifiers. In addition to continuity of service, other advantages

announced include quicker servicing, greater flexibility in arrangement of individual breaker poles within the metal enclosure, less aisle space required to remove and turn the breaker, and smaller inventory investment. The Type FB is also lighter in weight, simpler in overall construction and smaller in floor space requirements.

Manufacturer points out that cathode breakers are usually unnecessary when these anode breakers are used. Capable of interrupting small currents and picking up loads quickly, the FB can be tripped by external relays for overload or bus fault protection. In addition to complete removal, individual breaker poles may be racked out to two positions — one for test with control voltages still connected and another for complete disconnection. Switchgear Div., I-T-E Circuit Breaker Co.

19—SPRAY NOZZLES discharge at low pressures

For general service in discharging large quantities of liquids at low pressures, Fig. 627 Spray Nozzles produce medium to coarse, evenly distributed, solid-cone sprays with a normal spray angle of 70 deg. This pattern of distribution is reported particularly applicable to scrubbing of fumes, cooling of gases, gas washing operations and feeding liquids into packed towers. The nozzles come in 10 orifice sizes. With water supplied at 10 psig, the smallest discharges 1.2 gpm, the largest 120 gpm. With pressure increased to 100 psig discharge rates are 3.75 to 375 gpm. The nozzles will produce solid-cone sprays at pressures as low as 3 psig. Bulletin 6A-627 gives data. Schutte and Koerting Co.

20—WATER TUBE BOILER is ready for installation

Model AS, a packaged boiler, is available in capacities from 4000 to 13,000 lb of steam per hour. Its basic construction is the A type tube arrangement. According to manufacturer, efficient heat transfer and protection for refractory have been achieved without baffles; tangent tubes in the furnace wall eliminate refractory baffle between furnace and convection tube pass of boiler. The mechanical draft fan is mounted at the rear of the boiler, providing positive air cooling of furnace floor and front firing wall. This feature is also said to result in more uniform air supply to the burner and better flame formation. Rotary burners are standard on all sizes. Model AS Boilers are furnished complete even to refractory, insulation and steel jacket, and require no special foundation other than their own structural steel base. Superior Combustion Industries, Inc.

21—APPARATUS provides prepared compressed air

This method of providing compressed air dried, cooled and cleaned for use with instruments or controls and for processes where required, uses two of company's air machines in series — an after cooler and compressed air chiller. In the first stage, the Aero After Cooler receives hot air from the compressor and cools it to around atmospheric temperature by evaporative cooling. At this point an oil separator removes moisture and oil or dirt that has been condensed from the compressed air. In the second stage, the air chiller uses refrigeration to cool and further dry the air to meet specifications. Niagara Blower Co.

22—POWDERED MATERIAL for descaling of water systems

Magnus Super Scale Solve is introduced for removal of calcium carbonate and magnesium hydrate scale from heat exchangers, boilers, evaporators and other water systems. Its use eliminates handling of concentrated liquid acids, company points out. At a concentration of 8 oz per gallon of water, effectiveness of the material equals a 4.5 per cent solution of liquid acid, manufacturer states, and this solution removes light scale and rust formulations without appreciable action on sound metals. Through chemical reaction, the scale is converted into soluble salts which can be flushed away with water. A built-in indicator gives visual indication of solutions. Chemical solutions of Magnus Super Scale Solve are reported non-inflammable and non-explosive. Magnus Chemical Co., Inc.

23—600 PSI GLOBE VALVES with new design features

Fig. 848 series of forged steel globe valves are introduced for steam, oil, water and gas lines. They come in ¼- to 1-in. sizes with ratings of 600 psi at 910 F in carbon steel and 600 psi at 1030 F in chrome-molydenum steel. Ambient rating, at 100 F, is 200 psi. Screwed end

and welding end models are standard. Four high-strength molybdenum alloy cap screws hold the bonnet to the body. Only 40 ft-lb tightening torque is required, company states. A spiral-wound stainless steel-and-asbestos gasket seals the body-bonnet joint, and mating faces of this joint are machined to keep the gasket under controlled compression. The gasket remains resilient, it is noted, providing a tight seal between mating surfaces despite expansion and contraction due to thermal and pressure cycling. Edward Valves, Inc., Rockwell Mfg. Co.

18—V-BELT DRIVES offer savings in space, weight

V-belt drives in the Dyna-V line are announced as featuring smaller and lighter sheaves and V-belts of higher capacity at substantially lower cost. They cover horsepower capacities available in conventional drives. Savings in space, weight and cost are attributed to development of stronger metals for sheaves, and synthetic rubbers and fibers for belts. It is noted that with the Dyna-V line, most industrial drives can be handled with belts only ⅜ in. wide, and sheaves reduced in both width and outside diameter. These sheaves also tend to prolong bearing life.

Dyna-V Drives come in two standard groove sizes to meet all except the largest industrial requirements. Besides the ⅜-in. (nominal top width) size, 3V, company offers a 5V, or ⅝-in. size, for higher horsepowers. Sheaves in the 3V series, from one to 10 grooves, are for drives from 1 to 50 hp. The 5V sheaves take from three to 10 of the ⅝-in. belts, and handle drives to 200 hp. An 8V series of made-to-order sheaves and 1-in. belts serves requirements to 1500 hp. Taper-Lock bushings are used on Dyna-V sheaves. Dodge Mfg. Corp.

24—PROCESS PUMPS are tripod-mounted, vertical units

Figs. 3181 and 3182 are tripod-mounted vertical centrifugal process pumps having stainless steel or other corrosive-resistant metal liquid end or Goulds-Pfaudler glass pump liquid end. With stainless steel or other resistant metal end, the Fig. 3181 is intended primarily for two unusually difficult services: handling of highly volatile, inflammable, toxic, explosive or other dangerous liquids where pumpage must be isolated from the atmosphere; or pumping liquids at extreme temperatures (−320 to 550F) where liquid end of pump must be insulated from the bearings, mechanical seals, driver and free to contact or ex-

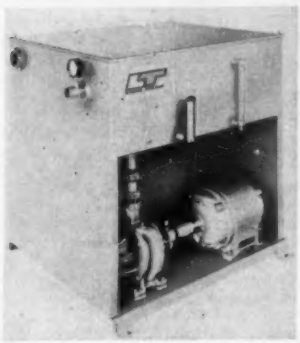
pand without binding and distortion. These pumps come in nine sizes from ¾- to 3-in. discharge, capacities to 800 gpm, heads to 300 ft.

Fig. 3182 Pumps, with Goulds-Pfaudler glassed pump liquid end, are for use where liquid to be handled is highly corrosive or where non-adherence of product or no metal contamination is required. All parts which come in contact with pumpage are glassed. These pumps are said to offer resistance to all acids except hydrochloric, even at temperatures to 350 F, and to alkalis at moderate temperatures. They give capacities to 700 gpm, heads to 140 ft. Goulds Pumps, Inc.

Reader Service Cards on pages 105–106 make it easy to get further information on any of these products. Just circle the item numbers of the products you want to know more about.

25—BOILER RETURN SYSTEMS are modern package units

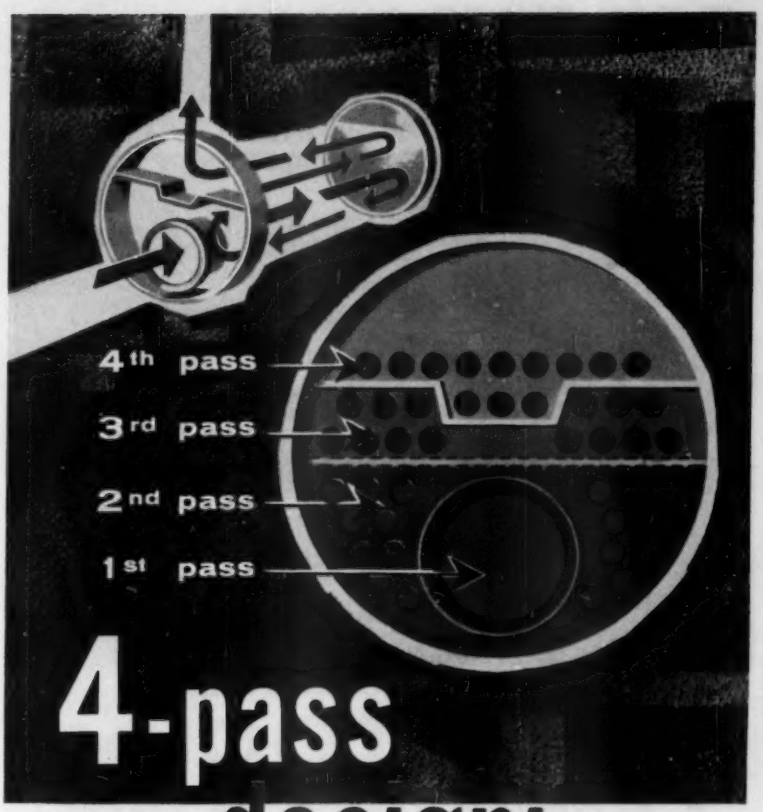
Modern in appearance, the Liqui-Therm Boiler Return System incorporates pump, motor and tank in a single, compact unit, ready to pipe. Standard systems are available for operation with boilers from 10 through 100 hp and



pressures to 200 lb. Three receiver sizes are offered, with 50-, 80- and 130-gal tank capacities. The units are furnished with turbine type pump or centrifugal pump. Pump and motor are housed within the unit, but accessible for inspection, and the tank cover is removable. Three return inlets are available. Largest unit in the line (130-gal receiver capacity) occupies a floor space of only 36-by-45 in. Full data provided in Bulletin 201. Liqui-Therm Products, Inc.

26—ELECTRICAL CONDUIT can be set, bent, cut by hand

Kopex, a pliable electrical conduit, is a tube formation composed of layers of continuous metal. It is claimed to afford maximum protection for cables and to be easily set and bent to negotiate corners and curves. It is pressure sealed to keep out oil or water. Manufacturer says that despite its pliability, this conduit remains almost rigid after bending and can be shaped to any radius without distortion of bore. It can be cut with a knife. Adapters facilitate joining conduit to standard electrical fittings, inspection



High fuel-to-steam efficiency for greater fuel economy

EVERY CLEAVER-BROOKS boiler has 4-pass fire tube construction — to scrub more heat from the flame. Maintains high flue-gas velocity . . . to provide right conditions for optimum heat transfer. This is just one of the Four Design Standards that make pre-engineered Cleaver-Brooks boilers your best packaged-boiler buy.

Other Design Standards

5 SQ. FT. OF HEATING SURFACE per boiler horsepower — prolongs boiler life, assures greater efficiency and lower maintenance.

FORCED DRAFT supplies air for efficient combustion, regardless of draft conditions. Easiest to maintain of all air-control methods.

UPDRAFT CONSTRUCTION — Low furnace keeps hottest combustion gases well below water level for safety's sake.

This exclusive combination of Design Standards is the key to the superiority of Cleaver-Brooks packaged boilers, 15 to 600 hp, 19 sizes, 130 models; steam or hot water; oil, gas or combination oil/gas fired.

For all the facts, call your boiler man from Cleaver-Brooks or write Cleaver-Brooks Company, Dept. A, 311 E. Keefe Ave., Milwaukee 12, Wisconsin.

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ORIGINATOR AND LARGEST PRODUCER OF PACKAGED BOILERS

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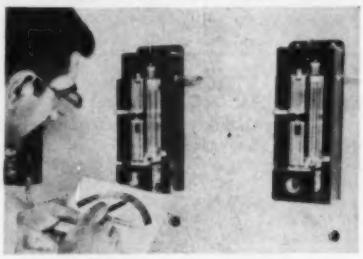
and junction boxes etc., company says, and a seal-tight end fitting provides a dry conduit system. Kopex can be had in continuous lengths or minimum 100-ft coils in standard electrical sizes from ½ to 1¼ in. It is available with PVC outer coating. Kopex can be made in formations of ductile materials and combinations of materials, as stainless steel, aluminum, copper and paper. Kopex Div., Gemmer Mfg. Co.

27—INSTRUMENT enables low cost colorimetric analysis

Announced as making colorimetric analysis simple and inexpensive, the Chemalyzer has no moving parts and needs no electric or pneumatic power for operation. It is powered by the gravity head of the entering sample and operation is continuous and automatic. It is stated that with it, untrained persons can make fast, accurate tests formerly requiring the work



of skilled technicians. According to manufacturer, the Chemalyzer costs only a third as much as conventional analyzers and enables tests to be made in a fraction of the time. In addition to monitoring chemical properties such as pH, residual chlorine, water hardness, phosphate and hydrazine or iron content in water solutions, this instrument can be used for titration control around a fixed end point.

The Chemalyzer mixes precise volumes of sample liquid and reagent to reveal sample properties colorimetrically. In operation, the sample is maintained at a fixed head in the sample reservoir and flows from there to the measuring chamber. Simultaneously, reagent is admitted to reaction chamber at a level of 3 cc. Entire contents of sample measuring chamber are then discharged into the reaction chamber to mix with reagent. Mixture is then siphoned into the optical cell. To take a reading, you compare graduations on a standard color chart with the sample in the optical cell. Florida Instrument Co., Div., Milton Roy Co.

28—SUBSTATION TRANSFORMERS are smaller and lighter

To help utilities meet rapid load growth in congested areas, this line of substation transformers is available in standard ratings up to 500 kva, 15 kv. The new units are announced as smaller, lighter and more efficient in all ratings than those they supersede. Compared to the equivalent 1948 model with tube-type radiators, a typical new 250-kva unit is 32 per cent lower, and 42 per cent lighter and requires 35 per cent less floor space. Compared with manufacturer's most recent panel radiator unit, the new model saves 30 per cent in floor space, 31 per cent in weight. Improvements are attributed to a redesigned core-

and-coil assembly and to new manufacturing techniques. Formex wire is used for turn insulation and rectangular instead of round coils are used to save space. Smaller panel radiators are mounted concentrically on the cylindrical tank. General Electric Co.

29—SHAFT MOUNTED DRIVE has increased torque rating

The 315GJ is an all-steel shaft mounted drive with increased torque rating of 41,000 lb-in. at the low speed shaft. With a ratio of 25:1, this unit covers a range of applications from 3 hp at 5 rpm to 30 hp at 50 rpm. Features announced include: extra-depth, high pressure angle helical gears with greater load carrying capacity and maximum mechanical efficiency; most all steel three-wall housing to maintain rigid alignment of revolving elements and to withstand external impact; inspection covers to check gears and bearings; dipstick for quick check of oil level. Bulletin 7100 Supplement gives details. The Falk Corp.

30—LIFT-STAND permits handling of cable reels

Heavily loaded cable reels are easily raised and positioned for cable pay-out, it is announced, with the portable Reelift. The device, using ordinary on-the-site conduit to extend lifting leverage, is

said to permit a lone workman to lift a 1152-lb reel as illustrated. Two men can raise larger reels weighing over a ton. Adjustable to various reel diameters, the Reelift has a welded base of reinforced angle-iron and measures 3 by 2 ft. Manufacturer says it accommodates reels with damaged or broken flanges and does not require jacks or accessory equipment. The Reelift handles up to 48-in. diam reels. Hykon Mfg. Co.

31—PACKAGED BOILERS with capacities to 100,000 lb/hr

Series 100-OG is announced as a line of natural circulation packaged boilers capable of generating steam at capacities up to 100,000 lb or more per hour. They are reported especially adaptable for electric utilities, and expected to cost about 20 per cent less than units of similar capacities erected at the site. Much of the cost reduction is credited to utilization of natural circulation — no recirculating pumps are used. Over-all maintenance costs also are lowered because practically the entire furnace and boiler envelope is water cooled. Also, initial refractory costs are minimized as less refractory material is required.

JOHN CRANE'S line of Chemlon Packing offers an unlimited selection of types, shapes and sizes for practically every service requirement:

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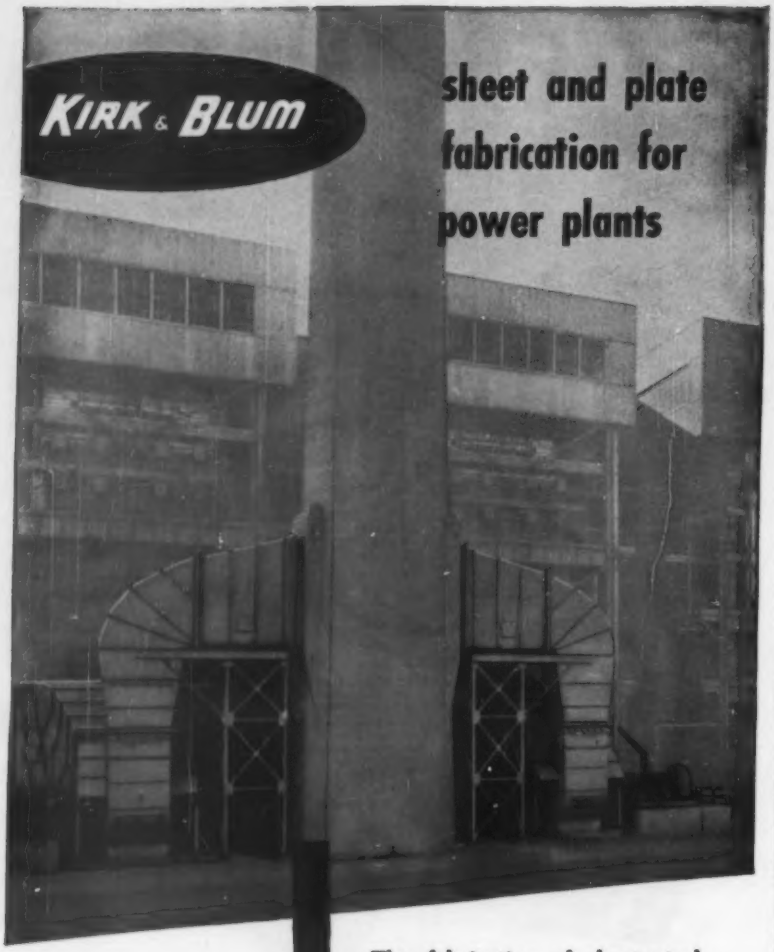

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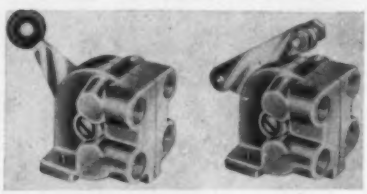
These boilers are designed to operate at steam pressures from 250 to 775 psi. Their wide furnace allows adequate burner clearance and contributes to complete combustion throughout range of capacities, it is pointed out; and because they are designed for pressure-firing an induced draft fan isn't required. They burn oil or gas or a combination. If a dual-fuel burner is installed, the stand-by fuel is instantly available, company notes, since one fuel can be lighted from the other. According to manufacturer, a feature of the Series 100-OG is the drainable superheater, cooled and protected with steam as soon as drum pressure is raised. Ease of draining the superheater promotes a fast, safe start-up and makes quick boiler storage possible, it is stated; it also protects against freezing-up of outdoor installations not in service. The Babcock & Wilcox Co.

32—SLIDING SEAL VALVES with threaded exhaust ports

This sliding-seal control valve has ¼-in. NPT ports and comes in two-, three- and four-way types with levers for hand or mechanical actuation. It is reported well suited for operating single or double acting cylinders with a 3-in. diam bore. The series of valves has a flow capacity



of 55 cfm, to accommodate larger cylinders, and features a piped exhaust port. It is pointed out that piping exhaust air to a neutral point eliminates air blasts and noises. The two- and four-way valves are designed so that any port can be the inlet port. Adjacent ports are outlet or cylinder ports and the remaining port on a four-way valve becomes the exhaust port. This permits neat installations without necessity to criss-cross piping. Porting on three-way valves is predetermined. A neutral position detent is provided on the four-way hand operated type to let the operator stop the piston of a cylinder and hold it in any desired position. A Shrader's Son, Div., Scovill Mfg. Co.

33—FLOW TRANSMITTER is mechanically frictionless

Described as entirely mechanically frictionless and liquid-free, Model 245 Flow Transmitter is introduced for measuring flow, liquid level or any other variable which is a function of differential pressure. According to company, transmitter has no torque tubes, stuffing boxes, knife edges or bearings. It is of the bellows-actuated type — the differential transformer core moves directly with the bellows. The only sensing unit is the single element bellows. Available in standard industrial ranges from 20 in. to 600 in. water differential, transmitter is specifically designed for use with company's electronic recorder. Together, these instruments form a system to measure, indicate, and/or record differential pressure. For pipe mounting, unit can be mounted on a vertical section of 2 in. pipe. Wall mounting bracket is also available. The Hays Corp.

continued from S-20

Several improved welding techniques that have been in course of development for some time are reaching, or have reached, the stage of widespread adoption. These improvements are particularly significant in three fields: (1) reducing the number of cases where it is necessary to maintain preheat without interruption from start to finish of a weld; (2) eliminating the need for backing rings; and (3) improving radiography. Brief mention of means for accomplishing these ends follows.

Interrupting Preheat

Where preheat is required or advisable, it should be maintained at least during actual welding operations. Until recently, however, it was advisable with ferritic-alloy steels to maintain heat without interruption from start to finish of the weld including stress-relieving even though the operators "knocked off" for the night or weekend before finishing a partially completed joint. This precaution often added considerably to welding costs. With the introduction of improved welding techniques including the use of low-hydrogen electrodes, tendency to cracking of partially completed welds was greatly reduced and it became practicable to interrupt preheat with certain alloys under prescribed conditions. These conditions are set forth in "Recommended Practices for Interruption of Heat Treatment Cycles for Low Chromium Molybdenum Steel Piping Materials" issued in 1955 in separate publications of the American Welding Society (D10.3-55T), and the Pipe Fabrication Institute (Es(M)-8-1955).

Eliminating Backing Rings

Much thought has been devoted to finding means for eliminating backing rings without losing their objectives of preventing weld spatter inside the pipe and giving the operator something to melt against in order to attain full penetration. Usually the approach is to use a special procedure for laying in the root pass, after which the weld is completed by conventional methods.

Double Welding

For large-diameter pipe or in favorable locations, it is possible to employ "double" welding, viz weld from both inside and outside the pipe. This approach is used, for example, in the manufacture of ASTM A155 welded-seam pipe and it can be used to advantage sometimes in attaching welding-neck flanges to pipe. The procedure is suited to either hand or machine welding.

Inert Gas Shielding

Inert-gas-shielded arc welding with non-comsumable tungsten electrodes is being employed to an increasing extent for laying in the root pass of pipe welds, particularly with austenitic stainless steels. In this process the welding arc is maintained between a virtually non-consuming electrode and the work, the arc being shielded by a flow of non-consumable gas such as argon or helium which is fed from a hose through the welding head. Filler metal of a composition resembling the pipe material is supplied from a bare rod similar to that used in oxyacetylene welding. Careful machining of the pipe ends to secure close fit of the lands is necessary with this method to compensate for the lack of backing rings. Several variations are in use ranging through no backup whatever, inert-gas-pressure backup from inside the pipe, and the use of fusible metal inserts in lieu of conventional backing rings.

Where no backup is used whatsoever, exceptional care has to be taken in machining the welding ends to close tolerances, protecting the ends from damage in transit from shop to job site, and in securing near perfect fitup before laying in the root bead. This method has been used in welding chromium-molybdenum main steam piping by at least one utility, with excellent results reported. In another known case, a small piping contractor in a remote district declined to undertake using this method because of the special requirements involved. He was able, however, to do an acceptable job by conventional welding methods using backing rings.

Inert-gas-shielded welding without backing rings has been used rather extensively for making root-pass welds in austenitic stainless steel piping where inert gas under slight pressure was also used for backup inside the pipe. Inflated bladders or equivalent are used inside the pipe to close both ends of the gas chamber which serves to keep pressure under the weld. Excellent results are reported, with practically no trouble from spatter or drip.

Consumable or fusible inserts, serving as backing rings, are used extensively in welding austenitic stainless steel pipe joints for nuclear work, generally with internal gas-pressure backup inside the pipe. These consumable inserts have to be completely fused in the root pass with the material being welded, the action being aided through surface-tension force drawing molten metal from the fusible insert into the root-bead area. Apparently these complex tension forces with internal gas-pressure support are enough greater than the force of gravity so that the solidified contour is essentially alike all around the joint. Considerable emphasis is placed on the importance of consumable-insert welding for nuclear power piping in order to avoid cracks or crevices at the root of the weld where radio-active material might lodge.

Improved Radiography

In welding pipe having a wall several inches thick it is advantageous to detect and correct any flaws in the deposited metal before too much additional metal is laid over them. With heavy-wall pipe radiographs are taken at one or more intermediate stages of a weld, as well as at the final stage, rather than waiting until it is completed before taking any pictures.

In one method called *hot radiography* the examination is made quickly without letting the weld cool appreciably from preheat temperature. Film is supported on a water-cooled holder surrounding the weld while the radium or equivalent capsule is inserted through the usual access hole in the pipe wall. Alternatively, pictures can be taken with the capsule outside the pipe as described later. This method is patented and either can be paid for on a royalty basis using leased equipment or obtained through an inspection service which sends out mobile equipment with laboratory and technicians.

Where partially completed joints in carbon and low-alloy ferritic steels are radiographed by ordinary methods they have to be allowed to cool slowly from preheat temperature to something approaching ambient temperature, usually a matter of several hours. With alloy steels such as 2¼ per cent chromium-1 per cent molybdenum that are more sensitive to thermal shock, the partially completed weld should be stress relieved at 1200 to 1300 F before it is allowed to cool to room temperature.

In conventional radiographic examination of welded pipe joints the radium or equivalent capsule is inserted through an access hole in the pipe wall and supported on a bent rod so as to center on the pipe axis beneath the weld. The film is wrapped around the weld on the outside of the pipe and the entire circumference examined in a single shot. A disadvantage of this method is the necessity for subsequently closing the one-inch diameter access hole. Various details for closing the hole are employed by different fabricators and erectors, many of which involve inserting a plug with straight threads for carrying the major pressure load, plus a seal weld for tightness on the outside of the pipe.

In order to avoid the access-hole problem, another approach is to place the radium capsule outside the pipe in one direction and wrap film around an arc on the opposite side. By taking shots through successive arcs it is thus possible to cover the whole circumference of the weld. Because shots have to be taken through two opposite pipe walls, it is necessary to take them in an oblique direction so as not to expose opposite sections of weld on the same film, thus confusing the location of possible defects. Each shot should go through unwelded pipe material in an oblique direction from the side of the pipe toward the capsule, and leave through an arc of weld metal on the side toward the film. Due to the geometric aspects of having to shoot through two walls superposed on one another, this method has a better chance of giving satisfactory results if the pipe diameter is relatively large with respect to the wall thickness. Although new as yet and not too well established, the idea of placing the capsule outside the pipe seems a promising way to avoid having to close access holes. THE END

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VALVES, TRAPS, AND PIPING

201 **Boiler Blow Off Valves** — Bulletin E-125, 24 pp, describes and illustrates the design and construction of company's quick-operating valves, angle valves, Y valves and duplex units specifically designed for boiler blow-off service. Includes dimensions. Everlasting Valve Co.

202 **Industrial Valves** — Condensed Catalog 105, 28 pp, contains data on valves for a wide variety of applications. Includes dimensions and illustrations, describing non-return (stop-check) valves, globe and angle stop valves, pressure seal design, angle univalves and small size globe valves designed for chain or extension operation in vertical lines. Edward Valves, Inc.

203 **Butterfly Valve Manual** — Forty-pp Catalog B-2 is designed to help power engineers select valve types, understand their characteristics, and determine space requirements. It includes such useful data as: pressure drop and flow tables, conversion tables, theory and application, recommended materials, and describes rubber seat butterfly valves from 4 in. diam up, for handling liquids and gases. The Henry Pratt Co.

204 **Choosing the Right Valve** — Presenting valve selection as a matter of matching the valve's service characteristics with service requirements of the job, this practical 20-pp booklet explains and illustrates basic design features of gate, globe and check valves. It tells, in non-technical language, how each of these valve types works, and where it is suited for use. Disc, stem connection, bonnet and bonnet-joint characteristics covered. Crane Co.

205 **Industrial Valves** — Bulletin 507V illustrates and describes company's line of industrial valves for control of air, gas, liquids and solids. Features photos and descriptive detail on a variety of valves, including butterfly valves, wafer butterfly valves, treaded butterfly valves, slide valves, check valves, proportioning valves and others. W. S. Rockwell Co.

206 **Steel Valves** — Catalog 120 contains 42 pp of detailed information on cast and forged steel valves, including gate valves, check valves and globe valves. A tables listing properties of ferritic and austenitic steels is included, as well as specifications and design data, dimension tables, dimensional diagrams, ring joint dimensions. The Chapman Valve Mfg. Co.

208 **For Lightest Condensate Loads** — Bulletin T1744 (58) describes company's No. 30 impulse steam trap for use where condensate must be handled in very small amounts. Lists advantages and applications, tells how trap works and gives capacities, dimensions, materials used, prices. Yarnall-Waring Co.

209 **Steam Traps** — Bulletin 455-B describes a float-thermostatic steam trap designed to discharge condensate at steam

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temperature continuously and without shock. Operation and construction features are outlined, and size and capacity data included. Sarco Co., Inc.

210 **Steam Trap Book** — Catalog K, 48-pp, is a manual of steam trapping practice. It includes a section giving physical data and prices on OF& T traps, cast semi steel and forged steel inverted bucket steam traps, compound traps, ball float air and air relief traps. A handbook section explains how to calculate condensate load, and select traps for all classes of equipment; a maintenance section explains trap installation, testing, and maintenance. Armstrong Machine Works.

212 **Insulated Piping** — Bulletin 57-1, 24 pp, on prefabricated insulated piping systems, shows typical uses for Hel-cor pipe units for underground or overhead pipe systems. Also describes Utilidor conduits for protection of underground utility services. Sample specifications and conduit sizing charts given. Ric-wiL, Inc.

213 **Industrial Expansion Joints** — Advantages of company's line of industrial expansion joints designed for rugged temperature and pressure extremes are detailed in this illustrated brochure. Typical applications are pictured. Solar Aircraft Co.

214 **Rotary Joints** — Described in Catalog 310 are rotary joints for use with steam, water, oil, air or gas, for temperatures to 450 F, working pressures 200 psi steam, 400 psi non-shock hydraulic. Illustrates design features, lists advantages, includes dimensional data. Also provides installation suggestions. Barco Mfg. Co.

PACKINGS, GASKETS, SEALS

215 **Mechanical Packings** — Catalog P-210C contains 40 pp of detailed information on company's line of mechanical packings and gasket materials. It contains illustrations, descriptions, complete service recommendations and specification charts. Raybestos-Manhattan, Inc.

216 **Mechanical Packings** — Featured in 24-pp Catalog 56 are several recent packing developments including the multi-purpose Bel-Vee V-Ring packings, the long wearing criss-cross braid packing series, twisted foil packings for oil and distillate temperatures to 1000 F, and an Inconel-wire reinforced plastic packing for valves handling superheated steam at temperatures up to 800 C. Packings for every industrial application are covered. The Belmont Packing & Rubber Co.

217 **Mechanical Packings** — Service and technical details on chemically-inert Teflon packings are provided in 8-pp Bulletin P-325 covering company's Chemlon line. Presents 15 types of braided construction, rings, six types of molded construction, cup and cone rings, combination sets. Gives recommendations as to services, applications and temperatures, also information on pressures, dimensions, mechanical requirements. Crane Packing Co.

PUMPS AND COMPRESSORS

218 **Controlled Volume Pumps** — Bulletin 953, 24 pp, describes and illustrates use of controlled volume pumps in industrial water treating systems. Construction and operation features are described, capacity-pressure ranges and speed and stroke length adjustments are charted. Typical chemical feed and water testing

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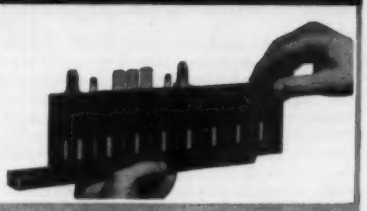

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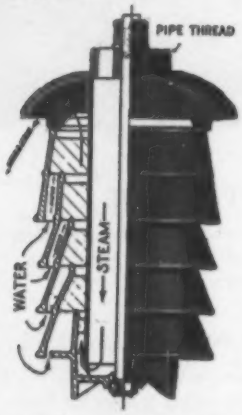

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systems are presented through text and diagrams; and an analysis of boiler water treating systems, cooling water treating included. Milton Roy Co.

220 Low Pressure Compressors — Eight-pp Bulletin A-95 describes a line of low pressure compressors for heavy duty industrial applications. Engineering design features are detailed and advantages explained. Joy Mfg. Co.

BOILERS, GENERATORS

221 Fire Tube Boilers — This 12-pp catalog describes Superior Compact packaged boilers in capacities from 20 to 200 bhp. Interesting arrangement of text, illustration and color is used to explain many features of the units. Gives complete data and dimensions for boilers designed for firing oil or gas or both. Superior Combustion Industries, Inc.

222 Package Boilers — This 12-pp booklet on package steam generators describes the formulas behind all package steam generators, and illustrates how installation of a package steam generator can raise steam capacity in an existing boiler room. Cyclotherm Div., National-U. S. Radiator Corp.

223 Steam Generators — Bulletin 55-1, 22-pp, describes company's products and services, including not only steam generators but also custom metal fabrication. There are many photos of boilers in various stages of assembly. Engineering drawings of boilers producing up to 500,000 lb of steam per hr on standard fuels are included, as well as illustrations of units for waste heat application and those designed to utilize refuse fuels. The Wickes Boiler Co.

224 Packaged Steam Generator — Advantages of company's baffleless, pressurized two-drum water tube packaged units are detailed in 12-pp Catalog SB-59. Features of the completely integrated generating plant, which requires no field piping, wiring, brickwork or special foundation, are shown on cutaway illustration. Erie City Iron Works.

226 Steam Generators — Twelve-pp Bulletin PSG-2 contains design and construction details on company's package unit steam generator — a vertical, bent tube, longitudinally fired water tube boiler. Capacities, dimensions and weights are tabulated and drawings, diagrams and photos showing fabricating methods included. Henry Vogt Machine Co.

228 Self-Contained Boilers — Bulletin AD-162, 8 pp, describes company's complete line of self-contained boilers for heating and processing steam or hot water. Design features and advantages are detailed and a cutaway view showing flow of air in the forced draft system is included. Cleaver-Brooks Co.

229 Integral-Furnace Unit — Bulletin G-94 describes the Type PFI integral-furnace boiler, a pressurized-furnace oil- and gas-fired steam generator for power, process or heating loads requiring steam capacities to 400,000 lb-hr. at pressures to 1150 psi and temperatures to 900 F. Includes information on membrane wall, integral combustion air duct and preassembled boiler components. The Babcock & Wilcox Co.

230 For Low-Pressure Heating — Guide Specifications GS-1, 58 pp, covers underfeed stoker applications to boilers best suited to commercial and industrial heating plants. Includes drawings of flexible layouts of the equipment, as well as specification criteria covering coal and ash handling, boilers, stokers and controls. Bituminous Coal Institute.

INSTRUMENTS, CONTROLS

231 Metering, Control Systems — Bulletin 500 describes purpose, design and operation of company's metering and control systems. Includes discussion of pneumatic and electric telemetering and pneumatic control, along with detailed literature references. Bailey Meter Co.

232 Resistance Temperature Detectors — In 8-pp Publication 3016D are described a line of remote temperature-sensitive elements for use in indicating, recording, controlling and monitoring equipment. Operations, application and construction details of the resistance temperature detectors are presented, along with specifications. Instrument Div., Thomas A. Edison, Inc.

233 Steam Calorimeter — This bulletin discusses an improved U-path calorimeter combining a throttling, separating and re-evaporating calorimeter in a single chamber. Explains construction and operation of unit. Ellison Draft Gage Co., Inc.

TUBING AND ACCESSORIES

234 Heat Exchanger Tubing — Cited in 30-pp Catalog A-205 are typical cases where cupro-nickel or Monel tubing installed in heat exchangers resulted in substantial savings and better efficiency through longer tube life. Describes appli-

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cations of this tubing in various instances where unusual water conditions, as to pollution, excessive turbulence, temperature and the like, required such tubing. The International Nickel Co., Inc.

235 Tubes and Plates — Publication B-2, 46 pp, covers the subject of tubes and plates for condensers and heat exchangers. Fields of application and particular problems encountered in each are described. Information on condenser tube alloys, plates for tube sheets and baffles, manufacturing methods, installation, operational factors affecting tube life, corrosion factors in condenser tube service is presented. The American Brass Co.

237 Life Extension for Condenser Tubes — The 32-pp current edition of this booklet reports on research into the causes of corrosion and means of combating them, as well as the choice of condenser tube materials. Points out that Admiralty metal, long a standard for power plant condenser tubes, works satisfactorily in most installations, but other alloys may be necessary in others. Revere Copper and Brass, Inc.

239 Tube Expansion Control — Bulletin 64 describes a tube expansion control which automatically controls expansion by accurate measurement of torque. Advantages are detailed and specification data furnished. Airetool Mfg. Co.

240 Electric Tube Cleaners — Bulletin E107 describes advantages and applications of company's electric tube cleaners for boilers, condensers, evaporators, and heat-exchangers. Tables are included giving complete specification details. Elliott Co.-Roto Plant, Div. of Carrier Corp.

241 Tube Expanders — Catalog 88, 119 pp, is full of detailed information about tube expanders and associated tools used for tube rolling. Profusely illustrated, catalog provides information relative to boilers, condensers, evaporators or miscellaneous heat exchangers. Special sections are devoted to expanders, accessories, measuring instruments, rollers, extensions and drives. Each type of equipment is described, application and engineering data included. Thomas C. Wilson, Inc.

COAL AND ASH HANDLING

242 Spreader Stoker — Advantages and features of company's continuous ash discharge spreader stoker are detailed in 24-pp Bulletin 40. Illustrates and describes operation details, and includes diagrammatically illustrated specifications, schematic diagrams showing installations with various types of boilers, and photos of typical installations. Detroit Stoker Co.

244 Coal Crusher — Company's WC and WS series rolling ring coal crushers are described in Bulletin 154. Emphasizes special construction elements that mean greater coal reduction at lower operating costs. Cross section illustration shows both feeding and crushing action incorporated and tables give capacities, speeds, and dimensions. American Pulverizer Co.

WATER CONDITIONING

245 Handbook on Demineralizing — Comprehensive 40-pp Bulletin 5800 compares various methods of water treatment, indicating the comparison between demineralizers and evaporators. It discusses the characteristics of the various types of available cation and anion exchange materials and offers data on operating costs of demineralizing. It tells when to use two-bed, three-bed, four-bed, mixed or mono-bed demineralizers. It also indicates when decarbonators or vacuum deaerators should be installed. Cochrane Corp.

246 Evaluating Steam Purity — Technical Paper 135, entitled "Conductivity vs Sodium by Flame Spectrophotometry In Steam-Purity Studies," discusses results of laboratory and plant work to indicate that sodium is extremely valuable in evaluating steam purity. Performance curves given. Betz Laboratories, Inc.

247 Boiler Water Treatment — Chemical reduction of oxygen in boiler feedwater with hydrazine is the subject of 10-pp Bulletin BW. Economy and operation, handling of the Deoxy-Sol, methods of analysis and other details are covered. A bibliography lists supplementary reading. Fairmont Chemical Co., Inc.

248 Corrosion Inhibitor — Bulletin 420-12-9 describes manufacturer's Composition TG, a sodium-zinc hexametaphosphate corrosion inhibitor for water systems, stressing its superioriry in controlling corrosion in water mains and cooling equipment. Provides comparative graphs showing flow coefficients, rate of film formation as determined by weight loss and current flow, and schematic drawings of feeding methods. Calgon Co., Hagan Chemicals & Controls, Inc.

249 Feedwater Treatment — Why boiler feedwater requires treatment and

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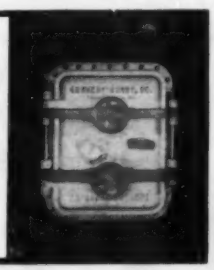

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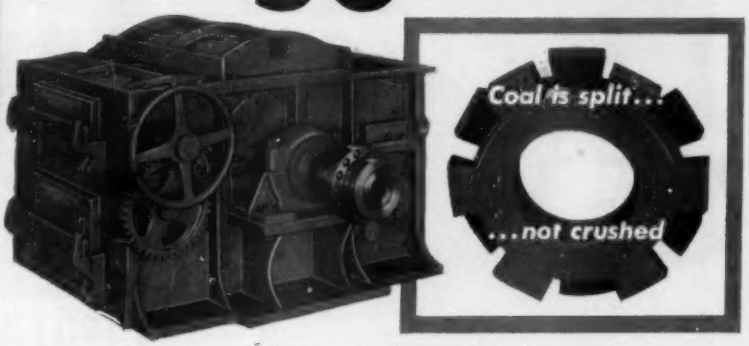

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how this company solves feedwater problems by conditioning water for use to best advantage under prevailing conditions is explained in this folder. Discusses scale prevention, corrosion control, suppression of foaming and carry-over, and sludge dispersion. Western Chemical Co.

250 pH and Chlorine Control — The 13th (1057) edition of company's handbook, "Modern pH and Chlorine Control," 100-pp, incorporating theory and practice of colorimetric analysis, serves as a reference for quantitative determination of pH, chlorine, phosphate, nitrate, sulfate, hardness and other tests. Slide comparators and complete test kits are illustrated. In addition to standard pH determinations, methods are outlined for quantitative analyses of phosphate, calcium magnesium, silica nitrate hardness. Available to qualified power engineers, please state your job title. W. A. Taylor Co.

251 Feedwater Heaters—Open-Coil, tray-type feedwater heaters and purifiers of both deaerating and nondeaerating type are presented in 12-pp Bulletin 117-A. Construction and operational features of the heaters are explained and illustrated, and more than a dozen available models are pictured along with application suggestions. They cover capacities from 3000 to 300,000 lb per hour. Stickle Steam Specialties Co.

253 Water Treatment Equipment — An outline of modern water treatment equipment is presented in this 10-pp Bulletin 4433. Discusses water impurities and methods of treatment, typical water-treatment systems, aerators, degasifiers, deaerators, chemical feeders, precipitation equipment, filters, and ion exchange equipment. Lists nine ways to demineralize water, by ion exchange. The Permutit Co.

LUBRICATION

254 Versatile Industrial Oil — Described in 20-pp Form AD 4078 is an all-purpose oil offering protection for a wide range of industrial equipment, and available in 15 viscosity grades. Discusses six major characteristics of the oil; explains and pictures its use in hydraulic systems, speed reducers, air compressors, electric motors, hydraulic turbines, bearing systems, etc. A chart shows grades available, uses, properties. Standard Oil Co. (Ind.)

255 Lithium Greases — This product information bulletin presents manufacturer's six Litholine industrial greases, stressing industry advantages offered by these multi-purpose greases. Gives properties of the greases, general application and performance characteristics and includes test data. Sinclair Refining Co.

256 Lubricants — Specification, Classification — Vital information on selection of lubricants is presented in 10-pp Vol. 41, No. 4 of "Lubrication." Covers such items as performance specifications, initial suitability of lubricants, quality of lubricant, effect of lubricant on production; effect on maintenance, effect on power, effect on cost, and features a look to the future. The Texas Co.

ELECTRICAL EQUIPMENT

257 Handbook on Fuses — This 12-pp booklet contains practical information on how to get safe, dependable, trouble-free electrical protection. Shows what to do when fuses blow, how to determine cause of blows, what kind of fuse to use for various circuits. Contains short history of fuses and notes on construction of fuses. Bussman Mfg. Co.

258 Cable Troughs — This 28-pp catalog offers a simple solution to any design problem of change of direction or elevation with a complete set of standard fittings, horizontal elbows, inside and outside vertical elbows, ties, crosses, covers and many special fastening devices to save time and labor. Contains full instructions for installations. The Globe Co.

259 Electrical Enclosures — Bulletin EE, 14 pp, describes company's line of sheet metal electrical enclosures and other related items for a variety of applications. Covers control desks, electrical cabinets and enclosures, power distribution and control panels, boiler, turbine generator control panels, switchgear housings, and others. The Kirk & Blum Mfg. Co.

Postage-free cards for ordering catalogs are on page 106. You may also use the cards to order literature mentioned in the ads.

260 Testing Instruments — Bulletin 19-58, 16 pp, features company's electrical testing instruments, including ohmmeters, ground testers, dielectric test sets, motor rotation tester, cable fault locating equipment, transformer turn ratio test sets, corona test equipment, frequency meters, tachometers, others. Includes photos and descriptions of each type, covering chief features. James G. Biddle Co.

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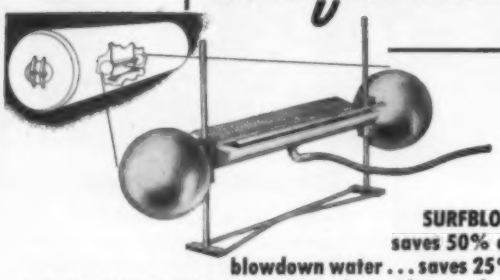

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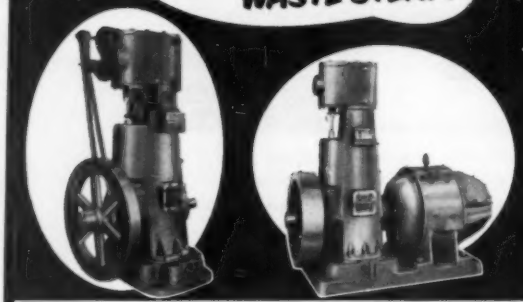

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OTHER EQUIPMENT

261 Steel Plate Construction — Pictured and described in this 20-pp bulletin are some of the steps in the fabrication of steel plate into boiler breechings, casings, duct work, stacks and special shapes, from initial design stage to final erection at plant site. The bulletin is generously illustrated with photos of typical plants utilizing these fabrications. They cover a wide range of industries, including paper, petroleum, steel, as well as utilities. Connery Construction Co.

262 Car Movers — Bulletin 60 E, 32 pp, presents car movers and some of their applications. Captstan and drum type movers are shown, along with portable units, also car hauls, railroad car retarders and mover accessories. Includes specifications and dimensional information, explains how to determine type and size of mover required. Illustrations show movers in typical and special uses. Webster Mfg., Inc.

263 Fuel Oil Conditioner — A fuel oil conditioner which dissolves all sludges, prevents new sludge from forming, excels as an emulsifier of condensation, holds water, sludge and oil in complete suspension and exhibits other performance advantages is covered in a recently published pamphlet. Kor Corp, Div. Oxi Corp.

264 Process Equipment — Bulletin G-3B describes equipment for process industries, including pneumatic conveying systems, compressors and vacuum pumps, coolers and preheaters, blowers, gas and vacuum pumps, fans and gas washers, accessories. In addition to describing features and advantages of the equipment, bulletin includes engineering data tables, photos and drawings. Fuller Co.

265 Cooling Towers — Featured in 20-pp Catalog DFA-58 is company's double flow Aquatower, combining high efficiency with low silhouette. Specifications and engineering data are included, as well as dimensional drawings showing construction features. The Marley Co.

266 Sheet and Plate Fabrication — Illustrated in 40-pp Bulletin F-3 are products of this manufacturer, and equipment used to produce special sheet steel and alloy parts. Shows control panels, switch gear housings, cubicles and other electrical enclosures, boiler air ducts, smoke breechings, tanks. The Kirk & Blum Mfg. Co.

267 Equipment Selector Charts — Bulletin CE-50, 20 pp, contains selector charts on corrosion-resistant equipment for process industries. Tables cover general considerations in selection of material, physical properties, corrosion resistance, techniques and skill in manufacture of equipment. Describes rubber and plastic pipe, tubing and fittings; valves; pumps; as well as lined tanks. Amerace Corp, American Hard Rubber Co.

268 Steam Engines — Bulletin 308, 8 pp, describes features and advantages of company's line of vertical type steam engines. Sectional drawings and engineering data table are included, as well as descriptions of construction details. Troy Engine & Machine Co.

269 Ventilation Units — Bulletin FM-315, 25 pp, describes basic construction of company's package propeller fans for commercial and industrial applications. Illustrated case histories of typical installations are included, as well as performance data. Buffalo Forge Co.

270 Corrosion, Abrasion Control — Modern practices and products for the positive protection of metal equipment from the effects of corrosion and abrasion are described in this 16-pp bulletin. Covers factory and field application of rubber or synthetic linings to metal parts or products, and maintenance coatings available. Goodall Rubber Co.

271 Steam Turbines — The advantages of company's solid wheel turbines, axial flow turbines, single stage and multistage, are outlined in illustrated Bulletin S-140. Describes various models in their line and includes application photos. The Terry Steam Turbine Co.

272 For Quiet Heating — Described in this bulletin is the HusHeater, designed to heat — without making a sound — water and liquids by introduction of steam into the liquid. Lists advantages of the HusHeater, explains how to install it and tells how to order. Most common application is in filter boxes and hotwells; other applications are in heating processes in sugar refineries, others. Sims Pump Valve Co. Inc.

273 Oil and Gas Burners — Bulletin OB-53, 28 pp, gives principles of selection and application of oil or gas burners, or a combination of both for standard and wide capacity range operation, together with air registers and fuel oil heating and pumping sets. Conversion table shows approximate relationships between quantity of oil burned, boiler capacity and air required for combustion. The Engineer Co.

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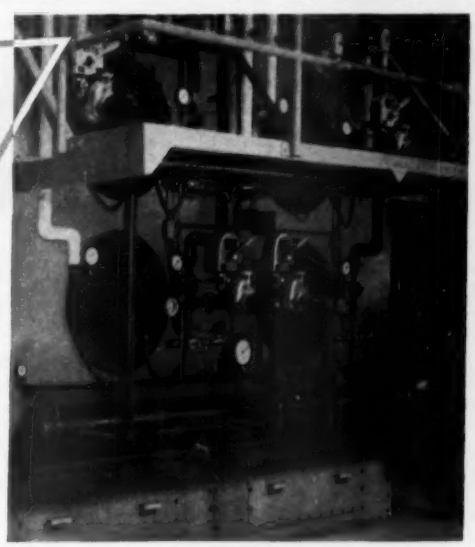

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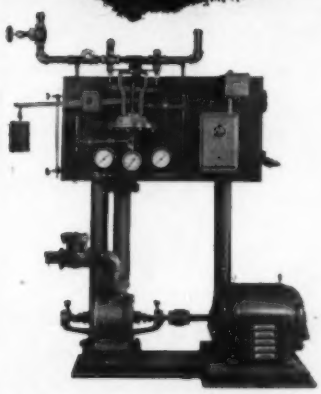
Cut Steam Costs

with Stickle's differential drainage and boiler return system



A closed pumping system for returning condensation from heating and processing equipment under pressure directly to boiler at temperatures only 15 to 20 degrees lower than those at operating pressure. For plants using steam pressures between 50 and 250 lbs. Cuts the cost of steam these eight ways:

1. Cuts fuel costs 10% to 25% by completely salvaging condensate and returning to boiler at 300 degrees or higher.
2. Raises production with higher, more uniform boiler pressure, higher temperature steam.
3. Reduces use of raw make-up water 85% to 90%.
4. Cuts maintenance on boilers, steam lines, traps and valves.
5. Improves quality by permitting operation of processing units at peak efficiency.
6. Cuts power used for pumping up to 75%, since system requires only 25 lbs.
7. Automatically maintains positive circulation without steam loss.
8. Eliminates flash steam waste.

FREE BULLETIN!
Write or wire for details and free Bulletin 250.

STICKLE STEAM SPECIALTIES CO.
2241 Valley Ave. • Indianapolis 18, Ind.
SINCE 1905

Stickle Equipment
Cuts the cost of steam

Steam Traps • Feed Water Heaters
Regulating and Reducing Valves
Drainage and Boiler Return Systems

For more data circle 551 on Post Card

FILL IN AND MAIL TO WESTERN CHEMICAL COMPANY

Kansas City 5, Mo.

Pioneers in the chemical control of problems relating to the use of water, steam and fuel

"I have a problem..."

- ☐ scale, corrosion, or foaming in my boiler operation
- ☐ rust and corrosion in my steam and condensate return lines
- ☐ scale, corrosion, or algae growth in my cooling or condenser water system
- ☐ corrosion or scale in my potable or plant water supply lines and tanks
- ☐ rust and corrosion in my brine or sweet water system
- ☐ scaled up pumps, water jackets, compressors, coils, lines, or equipment
- ☐ sludge and moisture in my fuel oil supply
- ☐ soot deposits in my furnace combustion areas

"I'd like to know..."

. . . exactly what specific treatment your Technical Services Dept. recommends. I understand that such problems have been your specialty for over 65 years and that you have an outstanding record for restoring and maintaining efficiency of plant equipment through advanced chemical treatment. Will look forward to receiving in the near future both your latest technical literature *and* a personal letter concerning my problem. I understand that my inquiry involves no obligation.

NAME_____ TITLE_____

FIRM_____

ADDRESS_____

CITY_____

ZONE_____ STATE_____

Mail to Technical Services Dept., WESTERN CHEMICAL CO.
717 Washington St., Kansas City 5, Mo.

For more data circle 552 on Post Card

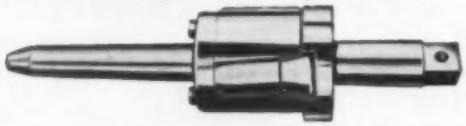
Keep boilers on the line with

WILSON Maintenance Tools

Heavy-duty air driven tube cleaners

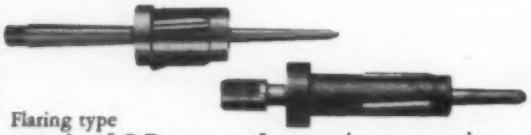
Designed to deliver maximum power at the most efficient cutter head speeds while negotiating sharp bends, the Model ECT Air Cleaners are excellent for cleaning curved boiler tubes from 2½" to 4½" O.D.

Self-feeding tube expanders



Wilson Model 38 tube expanders are self-feeding and parallel expanding. They are of the single flare roll type. Available for tubes 1" O.D. to 4½" O.D. with various roll lengths for tube seats ¾" and up.

Model E Expanders



Flaring type expander 1" O.D. to 4½" O.D. tubes, ½" to 2" tube seats

Long reach type expander 1" O.D. to 4½" O.D. tubes, 2½" to 5" tube seats

Right angle bevel gear drive

This Wilson bevel gear drive is expressly manufactured to meet continuous and heavy duty service conditions. The one piece all steel body is extremely rigid and not subject to distortion. The maintenance of perfect gear alignment is assured with consequent long service life.

Write today for your copies of Wilson Tube Cleaner catalog No. 77 and Wilson Tube Expander catalog No. 88.

Representatives in principal cities

Thomas C. Wilson, Inc. • 21-11 44th Ave., Long Island City 1, N. Y.

Cable address: "Tubeclean", New York

WILSON

TW870

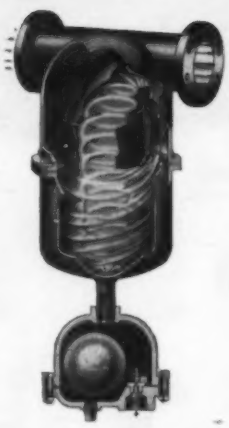
TUBE CLEANERS • TUBE EXPANDERS

For more data circle 553 on Post Card

New Design Assures Maximum Entrainment Removal With Low Cost "T" Separator

Redesigned annular passage increases centrifugal force. Separated moisture, oil and solids travel outer wall to lower collecting chamber. Large diameter, high level outlet reduces velocity, eliminates entrainment problems. Screwed ends ½" thru 3". 125 lbs. flanged ends 2½" thru 8". Low cost in-line installation.

Combined with No. 90AC automatic drain trap to prevent loss of steam, air or gas provides most efficient and economical separator-drain combination available.



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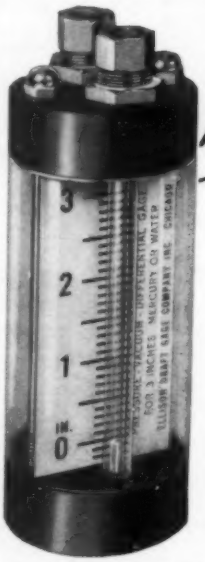
WRIGHT-AUSTIN COMPANY

3245 WIGHT STREET • DETROIT 7, MICH.

For more data circle 554 on Post Card



ELLISON Miniature Draft Gage

HAS STAMINA, ACCURACY OF LARGE GAGES. FOR PRESSURE, VACUUM, DIFFERENTIAL READINGS

Available in ranges of 0" to 3" mercury or water, 0" to 40" of water using mercury, also 0 to 24 oz. using mercury. Dia. 2", height 5⅜", weight 9½ oz. Heavy wall glass indicating tube with straight uniform bore, protected by transparent housing. Highly visible scale. Drain plug screw on side of reservoir. Nickel plated steel fittings. Easily disassembled for thorough cleaning. Modestly priced. Should be carried in all service engineers' kits or for use wherever accurate readings are required. Send for Bulletin 217.

MODEL P-1 SINCE 1896

ELLISON DRAFT GAGE CO.

550 W. Monroe St., Chicago 6, Ill.

ELLISON DRAFT GAGES "The Entering Wedge To Boiler Room Efficiency"

THE ELLISON LINE ALSO INCLUDES:

Draft Gages, Bell and Diafram — Inclined Draft Gages — Portable Inclined Vertical Tube Gages — Vertical Tube Gages, Oil, Heavy Liquid and Mercury, Single and Multi-Tube — U-Gages, Stationary and Portable — Air Filter Gages, Dial and Inclined Tube Types — Pitot Tubes — U-Path Steam Calorimeters — Portable Gas Analyzers, Orsat Type — Alarm Systems.

For more data circle 555 on Post Card

A Websterama OF ECONOMICAL COAL HANDLING

Twin track hopper receives run-of-mine coal from cars assisted by car shaker, and loads double reciprocating plate feeder.

Plate feeder discharges to inclined Belt Conveyor #1–212' long. Magnetic pulley ejects tramp iron at discharge to crusher or by-pass chute.

Under crusher, coal can be fed to Conveyor #2 or #4. Coal sampling equipment is located in chute to Conveyor #2. Inclined Conveyor #2 is 341' long from crusher house to Conveyor #3 (over bunkers in main building).

Conveyor #3, equipped with automatic self-propelled Webster tripper, distributes coal to 104' long bunker. Each compartment of bunker has Webster gate and scale to automatically record fuel used.

Stocking-out Conveyor #4 is 43' long and discharges to yard storage. Coal is reclaimed through system as previously described.

The complete coal handling system is electrically interlocked for movement of coal without fear of jam-up.

This WEBSTER 300-ton-per-hour coal handling system built for the City of Richmond, Indiana, could well be described as "an introduction to automation." It was designed to meet the most modern requirements for automatic, efficient handling of coal, with a minimum of maintenance and operational attention. In addition to the conveying system, WEBSTER also supplied the masonry crusher house, which includes dust-tight control room, locker room, bulldozer garage, plus crusher room and sampling equipment.

Whether you intend to construct a new power plant or modernize an old one, WEBSTER engineers will be pleased to cooperate with your engineers or engineering firm in applying 81 years of WEBSTER experience to your coal-handling problems. Write Dept. TE-19 today.

WEBSTER MANUFACTURING, INC.
Dept. TE-19 **TIFFIN, OHIO**
Offices in All Principal Cities

ELEVATING AND CONVEYING MACHINERY • SINCE 1876 •

Consulting Engineers
BLACK & VEATCH
Kansas City, Mo.

All component parts were built in the Webster plant at Tiffin, Ohio.

Webster

SINCE 1876
BULK MATERIALS HANDLING EQUIPMENT

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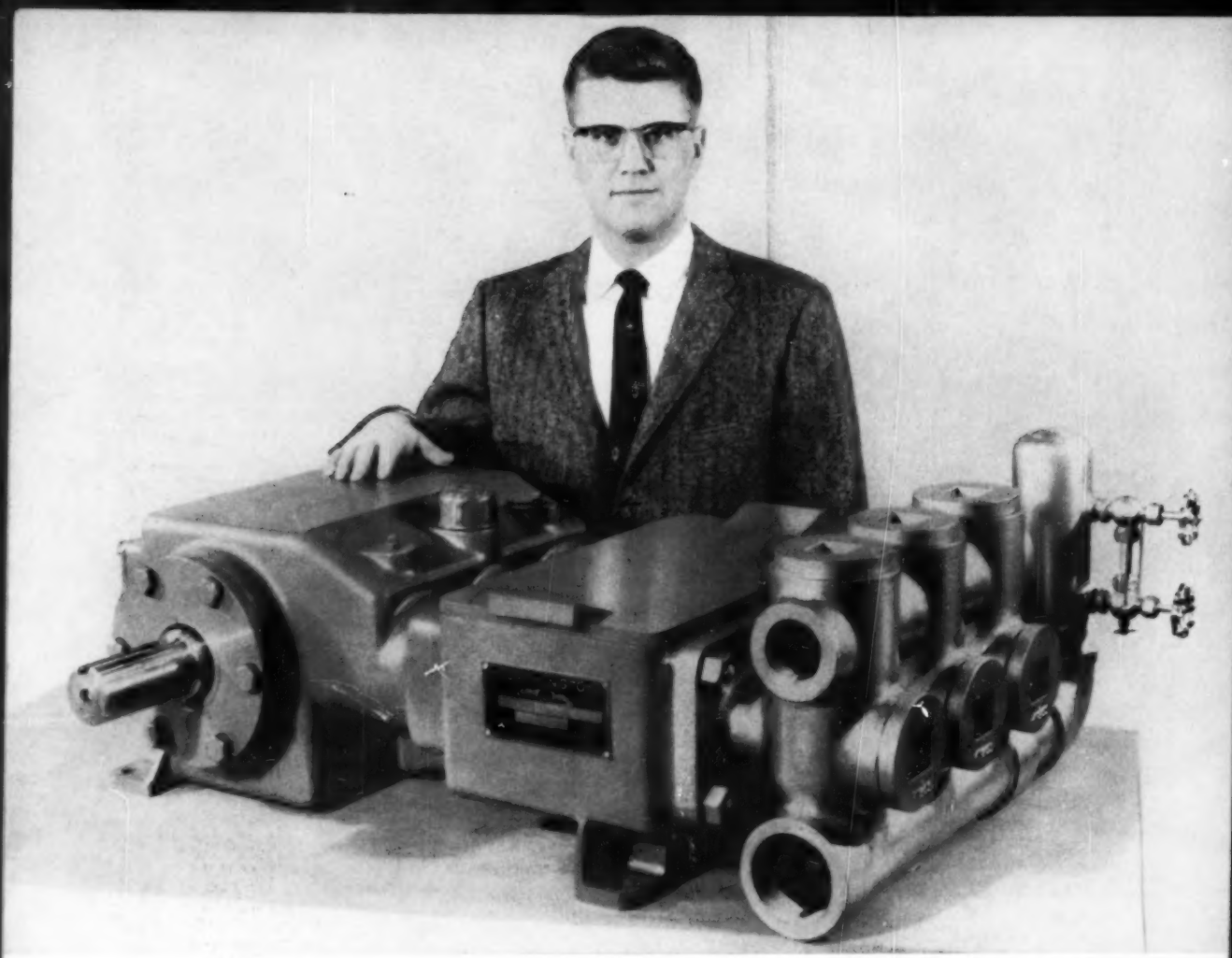

NOW! A HIGH PRESSURE PUMP AT A NEW LOW PRICE

Before you buy a high pressure pump for accumulator systems or other hydraulic applications, you should see the new Worthington KCA. On any problem requiring reliable high pressure, you can depend on the KCA to give you: highest capacity of *all* comparable competitive models, more pressure, and a truly low price. Charts below prove it. You get fully 23% more gallons capacity per day. You get at least 100 psi more than the next best pump. And your cost per input horsepower is only $38.

Check these 5 extra economy and efficiency features yourself:

1. **High volumetric efficiency** made possible by straight-flow design and "close-clearance" liquid end construction.

2. **Maximum stuffing-box accessibility** due to lack of partitions in power end cradle.

3. **Many "extras" included as standard** such as suction air chamber to minimize noise and pulsation, plunger packing and stuffing box cover.

4. **Flooded suction adequate** because large pipe connections minimize friction. 3" suction, 2" discharge on either side.

5. **Less valve wear** resulting from guided, wing-type valves that are self-grinding. Liberally-sized suction and discharge valves both removable through single top covers.

Some of the many applications for the new KCA pump include hydraulic presses and shears, steel mill roll balance, die casting, boiler feed service, descaling, cleaning and washing, fog spraying, hydrostatic testing, and rifle drilling coolants.

For complete details, contact your nearest Worthington district office. Or, if you prefer, write: Worthington Corporation, Section 32-3, Harrison, New Jersey. In Canada, Worthington (Canada) Ltd., Brantford, Ontario.

WORTHINGTON

HIGHEST CAPACITY

Worthington KCA	98600
Brand A	78120
Brand B	66780
Brand C	54000
Brand D	44310

MAXIMUM CAPACITY IN GALLONS PER DAY*

*At normal ratings. Some manufacturers, including Worthington, will permit higher speeds, capacity and horsepower after approving suction conditions. Best performance, however, is obtained by staying within normal ratings.

MOST PRESSURE

Worthington KCA	3100
Brand A	3000
Brand B	3050
Brand C	1490
Brand D	1550

MAXIMUM PRESSURE–PSI

LOW COST

Worthington KCA	$38
Brand A	35
Brand B	46
Brand C	58
Brand D	47

COST PER INPUT HORSEPOWER–NORMAL RATINGS